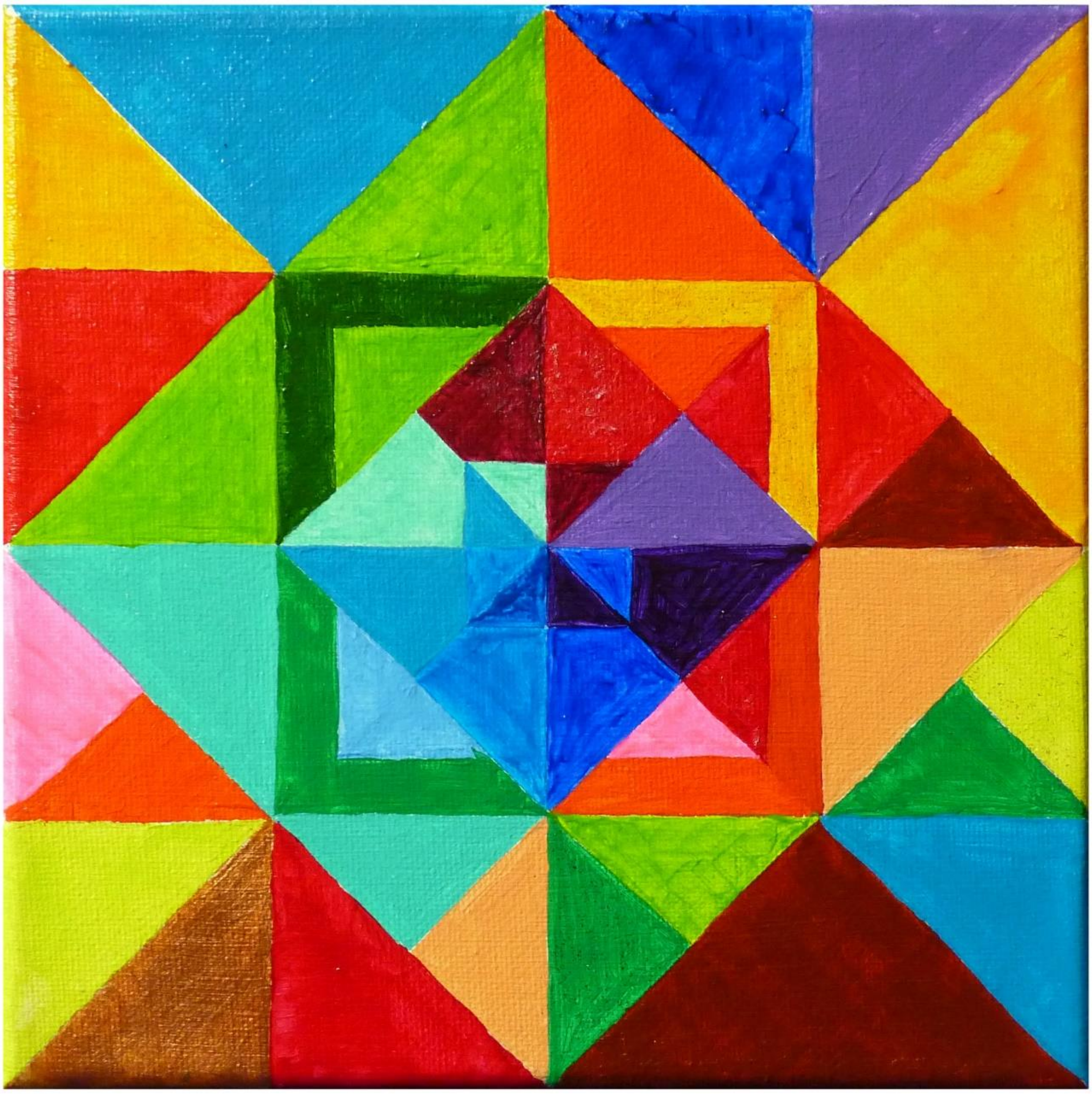
Design
beyond probability



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CONTENT

"De gewoonten der menschen is zodanig, dat zy, zo dikwijls als zy enige gelijkheit tusschen twee dingen bemerken, van beide het geen oordeelen, 't welk zy van een van beide waar hebben bevonden, zelfs hier in, daar in zy verscheiden zijn." [a]

People have the habit, as soon as they recognize any equality between two things, to suppose that equality in everything, even in which those things differ.

"Er is geen ander zijn dan anders zijn"[b]

There is no other being than being different.

a Descartes(1684)Regulae ad directionem ingenii Regulen van de bestieringe des verstants(Den Haag 1966)Nijhoff
b Bruggen(1924)De grondgedachte van Prometheus(Amsterdam)Maatschappij voor goede en goedkoope lectuur

FOREWORD

My parents told me not to generalize, but they sent me to schools, where they taught me how to generalize. At 'the age of discernment' I chose a design study in order to learn *generating* instead of *generalizing*.
In 1972, however, I still believed that design should be a science.

With some fellow students architectural and urban design at the Delft University of Technology, I wrote a manifest[a] of 100 propositions in order to convince our Faculty of Architecture to scientize.
Glegg(1973)[b] seemed to agree, calling his book: "The science of design".

The study of empirical research methods[c], however, disappointed me, my fellow students and our design teachers. It opened our eyes for the *truth* of the *existing* reality, but to design new *possibilities* required definitely different methods.

Simon(1982)[d], still did not satisfy. He recognized a different logic for design, the importance of boundaries between inner and outer worlds of artifacts[e], but he still described design as scientifically 'solving a problem'. As Cross(1982)[f] advocated, in addition to sciences and humanities, a *third field* should be recognized: design.

In 1983 the Scientific Council for Government Policy of The Netherlands (WRR) published a policy-oriented future exploration.[g]
It distinguished probable, desirable and *possible* futures, stressing the last in 1983.

In 1984, Frieling, Zwarts, Van Engelsdorp Gastelaars and Rijnboutt initiated a 'Netherlands Now As a Design' (NNAO) foundation[h]. They invited 4 leading Dutch designers to design The Netherlands in three 'desirable' and one 'possible' scenario.

I had to write their Socialist, Christian Democratic, Liberal and 'Possible' program. With my students and programmer Kyrkos I made a computer game that would allow anyone to design The Netherlands on its current map appearing on the screen. At each intervention on the map 4 dolls (4 political parties) appeared laughing or crying.

In 1988, at the major exhibition of the designs and the game in Amsterdam, four politicians of the different parties publicly played this game, drawing their future. The doll of their respective party did laugh indeed each time.
We managed to fit probable, desirable and possible futures in one algorithm.

a Jong(1972)Honderd stellingen van Sharawagi(Delft)Sharawagi http://www.taekemdejong.nl/Publications/1970tot1980/Sharawagi%2001.doc
b Glegg(1973)The science of design(Cambridge 2009)Cambridge University Press
c Groot(1961)Methodologiegrondslagen van onderzoek en denken in de gedragswetenschappen(DenHaag)Mouton
Baarda;Goede(1990)Basisboek methoden en technieken - handleiding voor het opzetten en uitvoeren van onderzoek(Leiden 1990)Stenfert Kroese
d Simon(1982)The Sciences Of The Artificial(CambridgeMass)MITPress
e Lawson(1990)How designers think, the design process demystified(Oxford)Butterworth Architecture p70 specifies internal and external constraints.
f Cross(1982)Designerly ways of knowing(Design studies)vol3 no4 Oct p221-227
g WRR(1983)Beleidsgerichte toekomstverkenning Deel 2('s-Gravenhage)Staatsuitgeverij
h https://zoeken.hetnieuweinstituut.nl/nl/archieven/details/NNAO/section/allied/path/3.2/start/0

0 FOREWORD

Frieling, a 'founding father' of newtown Almere in The Netherlands, and a professor regional design in Delft, described his conception of the role of politics[a] (desirable) and research[b] (probable) in design (possible)[c].

In 1988[d], however, I positioned probability *inside* possibility, both partly overlapped by the desirability (***Fig. 3*** p15). Science (probabilities) *itself as a design* (possibilities)[e] liberates designing from *only* scientific methods.
Design is not the *third field* of Cross(1982). Science and humanities *are* designs. Glanville(1999)[f], cited by Vahidov(2012)[g] seemed to agree later.

This goes beyond the many attemps to find the secret of design methods by *showing* existing designs[h], *analyzing*[i] and *comparing*[j] them, *interviewing* designers, design students and design teachers[k], studying the *phases* of existing design processes[l], making *schemes* ('maps') of necessarily successive steps in a design process[m].

In these studies, the very start of any design process is mainly its *objective*, stating an aim, a purpose. This objective, however, is seldom one single purpose. It is mainly a vague and wicked[n] *field* of purposes[o] causing problems, stemming from a physical, technical, economic, cultural and organizational *context* at different levels of scale.[p]

A designer often summarizes them directly in a rough solution[q], a hypothesis, a 'design concept', to be evaluated and detailed in the next steps of known methods. The reverse, a rough solution confronts the client with the *field* of problems (s)he supposed or evokes. Any different solution, however, evokes different problems.

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a Frieling(2009)De politieke dimensie van ruimtelijke ordening(Rooilijn)6
b Frieling ed(2006)Research on New Towns(Almere)NTI
c Frieling(2002)Design in strategy IN Jong;Voordt(2002)
http://www.taekemdejong.nl/Publications/2002/56%20DESIGN%20IN%20STRATEGY%20from%20Jong(2002)WaysToStudy(Delft).pdf
d Jong(1988)Inleiding Milieuplanning(Delft)TUD Intreerede, inaugural address.
http://taekemdejong.nl/Publications/1988/Jong%281988%29Inleiding%20Milieuplanning%28Delft%29TUD%20Intreerede.pdf
e Eekhout;ed(2005)Delft Science in Design(Delft)Delft University of Technology Faculty of Architecture Chair of Product Development
f Glanville(1999)Researching Design and Designing Research(Design Issues)15 2 Summer p80-91, and many following publications.
g Vahidov(2012)Science as design IN Design-Type Research in Information Systems: Findings and Practices(Montreal)Concordia University
h Numerous publications that can be summarized as art historical, showing the product of design, but not its process.
i eg Leupen; Grafe; Körnig; Lampe; Zeeuw(1997)Design and Analysis(Rotterdam)Uitgeverij 010, or Hoeven;Louwe(2003)Amsterdam als stedelijk bouwwerk Een morfologische analyse(Nijmegen)SUN and other publications, eg referred in Jong(1995).
j eg Jong(1995)Systematische transformaties in het getekende ontwerp en hun effect(Delft)Diesrede, Speech on the University's birthday.
http://www.taekemdejong.nl/Publications/1995/Jong(1995)Systematische%20transformaties%20in%20het%20getekende%20ontwerp%20en%20hun%20effect(Delft)Diesrede.pdf
k eg Schön(1985)The design studio, an exploration of its traditions & potential(London)RIBA publications Limited, and many following publications, Dorst(2015)Frame Innovation(Cambridge Mass)MIT and Dalke;Evans;Self(2013)Designerly Ways of Knowing and Doing(EKSIG)
l eg Jong;Voordt eds(2002)Ways to study and research urban, architectural and technical design(Delft)Delft University Press
http://www.taekemdejong.nl/Publications/2002/Jong(2002)WaysToStudy(Delft).pdf
m eg Roozenburg;Eekels (1996) Product design - fundamentals and methods(Chichester)WileySons, Eekhout(1997)POPO of ontwerpmethoden voor bouwproducten en bouwcomponenten(Delft(Delft)DUP, later in English: Eekhout(2008)Methodology for product development in architecture(Amsterdam(Delft)IOS press and many of his other publications.
n Buchanan(1992)Wicked Problems in Design Thinking(Design Issues)8 2 Spring p5-21
o Lawson(1990)How designers think, the design process demystified(Oxford)Butterworth Architecture p37-97 specifies the connected problems with different weights to be balanced differently in each specific context. Their weights depend on many more or less valid ***suppositions***.
p It's not so wicked. In 2005 I developed a computer program 'FutureImpact' in order to analyse the *possible* impacts of a particular design project *desired* by the stakeholders in the *probable* future context they expect. See Jong(2007)Operational context analysis as a part of design related study and research (WSEAS EEED)07 http://www.taekemdejong.nl/Publications/2007/JongContextAnalysis.ppt.
The application for students is still downloadable from http://www.taekemdejong.nl/Publications/FutureImpact.zip
q "every formulation of a wicked problem corresponds to the formulation of a solution": Rittel;Webber(1972)Dilemmas in a General Theory of Planning(Berkeley)working paper presented at the Institute of Urban and Regional Development, University of California, Berkeley, cited by Buchanan(1992)p16. Alexander(1977)PatternLanguage(Oxford)OxfordUniversityPress saw the problem of many relations simultaliously earlier: Alexander(1968)The Atoms of Environmental Structure(Cambridge Mass)MIT Press

A solution to the field of problems evoked by that solution itself revolves in a circle. There is no method for *inventing*. Eekels(1973) already recognized that shyness in his "Industrial goal development"[a] as a painful leak in methodology.

In 1992, my "Little methodology for design study"[b], I attempted to to stop this leak. I defined an aim as a *desired, improbable possibility*, and a problem as an *undesired probability*. I did not start by an objective, exploring the steps of design *forward*, but *backward* into its tacit *suppositions* of desirability, probability and possibility.

Art, design, science and humanities *change suppositions*, as humor (Latin 'fluid') does during a joke. Creativity is the ability to forget, replace or add hidden suppositions.

I recognized a conditional *sequence* of suppositions. If you cannot imagine Y witout X, then Y 'supposes' X (X 'enables' imagining Y). It became an educational means to discover why students did not under-stand my Y. They missed my sub-posed X.
So, I began to study the conditional *sequence* of tacit suppositions.

The assumption that science is a design, forced me to include scientific suppositions. I defined 'knowledge' as a set of shared *suppositions*.[c] I then could also include the 'tacit' or 'implicit' knowledge, often mentioned in interviews with designers[d].
Words are not always sufficient to evoke the intended *images* tacitly *supposed*.

Any imagination of objects rests on a sequence of suppositions, images not always expressible in words. The same object may be imaginable by different suppositions, but the same suppositions also may produce different images in different subjects.

Some images are reached by detours along unnecessary suppositions, others even *cannot* be reached (unimaginable) by useless suppositions.
Which suppositions are necessary?
This study attempts to remove unnecessary suppositions blocking imagination.

The ability to *observe* and *imagine* any object, both suppose *difference* from the rest. The ability to imagine *different* objects supposes even more, but how to imagine an object that still does not exist? There is only a wicked context[e], including the many objects you may remember as images, easily, but not usefully filling the empty object.

Hertzberger's 'Avoid clichés, collect images, put them in a different *context* and adjust them'[f] is the shortest and most concrete recommendation for designers I know.
It leaves, however, some questions unanswered. Let me try to answer them.

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a Eekels(1973)Industriele doelontwikkeling(Assen)Gorcum p140
b Jong(1992)Kleine methodologie voor ontwerpend onderzoek(Meppel)Boom
c Popper(1963)Conjectures and Refutations(London1972)Routledge
d eg Dooren(2020)Anchoring the design process(Delft) University of Technology Thesis
e I use 'context' where Buchanan(1992) uses the wordt 'placement', and Dorst(2015) 'frame'.
f Hertzberger(1999)Space and the architect: lessons in architecture 2(Rotterdam)010 Publishers; Hertzberger(2002)Creating space of thought in: Jong;Voordt; eds (2002) Ways to study and research urban, architectural and technical design (Delft) DUP Science chapter 42, p 389

1. SCIENCE SUPPOSES DESIGN, NOT THE REVERSE

§ 1 DESIGN GOES BEYOND PROBABILITY

Human imagination may construct *probable* pasts and futures as produced by probability-based empirical research, but also *improbable*[a] ones. Some of these are realisable, *possible*. You may *invent* them by *design*, but imagination is often blocked by unconscious suppositions. This study aims to unmask such blockades.

Some possibilities can be explored by mathematical models extrapolating actual realities as probable by repetition. That may simulate improbable possibilities never observed or imagined before. They are, however, limited to what can be reached by *repetitive* operations. Repetition is the core of mathematics, but not of design.

Exact repetition of *equal* units results in *numbers*. There are, however, different kinds of units, resulting in different kinds of numbers. Their *difference* is usually indicated by the *name* of variables, expressed in the different characters of algebra.

Operations on numbers such as adding, subtracting, multiplying, dividing, powering, integration or differentiation, suppose repetition as well. Iteration may produce a kind of diversity (eg fractals), but that covers only a part of all possibilities.

The diversity of living nature shows many more possibilities based on *non-exact* reproduction and so does design. In evolution, only *different* genes can produce new combinations. Without any mutation, a combination of equal genes would never have produced the diversity required for the evolutionary survival of some new 'fittest'.

Design does not copy or repete equal things either. It makes something *different*.
It may combine old things, but then only the combination itself may be new.

For an empirical scientist, designers are liars: they draw things that are not *true*.
The modality of design, however, is not *truth*, but a wider concept of *possibility*.
What is true must be possible by definition, but the reverse, not everything that is possible is also true. What is true is therefore a subset of what is possible.

That is why I consider any science to be a design, but design not as science only.
Science seeks truth, equality, repetition. Design looks for new possibilities, making a *difference* from what is actually true. Science attempts to recognise *equality* and repetition. Only repetition enables to predict and anticipate.

Cusanus(1440)[b] already claimed that in reality absolute equality does not exist.
Also measuring or constructing are never completely accurate.
So, the exact world of mathematical concepts and relationships cannot be anything else than an *ideal* image of recurring experiences.

All apparent 'equality' amounts to not more than similarity.
Moreover, even mathematics should *distinguish* the proper variables first, before it

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a Strictly spoken any event has a probablity, but I will use the word 'improbable' as an abbreviation for 'with a very low probability'.
b Cusanus(1440)De Docta Ignorantia II, 1 p92 https://urts99.uni-trier.de/cusanus/content/fw.php?werk=13&ln=hopkins&hopkins_pg=61

may compare, conclude equality, summarise and divide.[a]
A creative mind, however, goes beyond repetition. Creation *makes a difference*.[b]

Van Leeuwen[c], took equality as the limit of difference, its unattainable zero value. Something different can always be imagined as more different, but not always as less different. If you no longer can observe or imagine less difference, then you may *call* it 'equality', but you still suppose at least two *different* objects in order to compare them and to conclude their '*equality*'.

You can count only things that are similar in one way or the other, but you have to be aware that they may differ in other respects.[d]
They at least must differ in location, otherwise they are 'identical', the same thing.

Words generalise repeating truths, probabilities, and causalities.
These are the core of empirical science, but design requires more. What is its surplus?
In order to specify in what sense design outreaches science, I take

1 equality as a special case of difference,
2 truth or probability as a special case of possibility,
3 science as a special case of design,
4 cause as one condition between the many conditions to be fulfilled, and
5 verbal language as a limited representation of imagination.

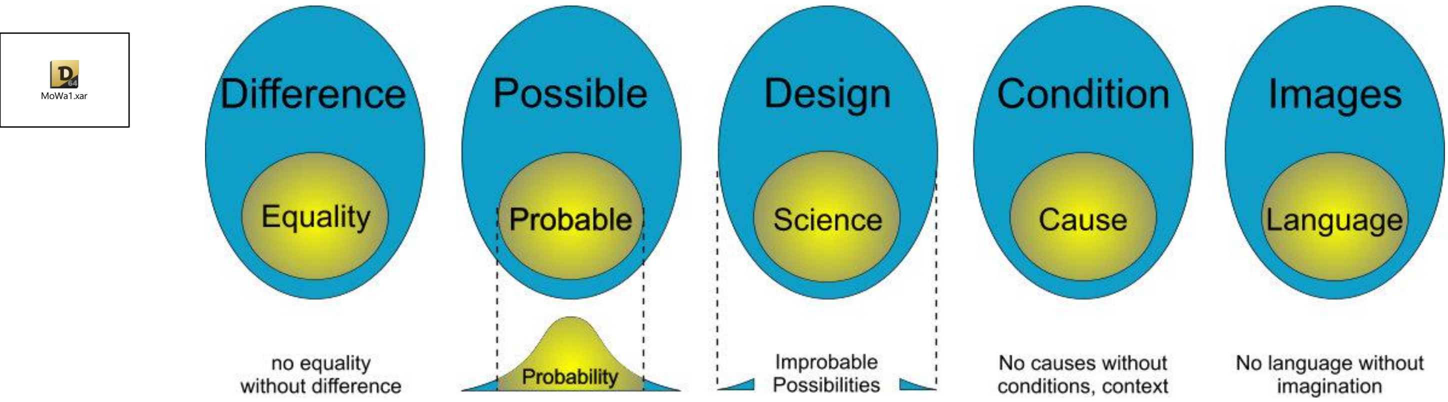

Fig. 1 Primary suppositions of this study

These starting points liberate *design study* from the limitations of *empirical research*.
Science *supposes* design (design *includes* science), not the reverse.
Generalizing supposes generating.
This subordination to design will not easily be accepted by scientists,
and designers will not accept easily that they cannot be considered fully as scientists.

Words generalize. They summarize a set of unique but similar experiences in a sound or code. A combination of words demarcates smaller subsets within these sets.

a Cusanus referred by Dijksterhuis(1975)De mechanisering van het wereldbeeld(Amsterdam 1980)Meulenhoff p250
b According to Anaximandros (as early as ca. -575), creation also consisted of separating opposites from the indefinite (apeiron).
c My teacher and predecessor as a professor in ecology at the University of technology in Delft.
d The statistical (epidemiological) approach to people in medicine is therefore doubtful.

As a result, each succeeding word in a sentence limits the scope ('extension') of the previous words and vice versa. We can finally experience an increasingly smaller subset as a 'description' of a specific experience or imagination.

A description in words can therefore only arise from a combination of generalizations. You can make new combinations, but each subset is always composed of generalisable experiences that we already suppose to share through words.

Each subset of generalizations is also a generalization.
What you call 'description' is then at most a 'circumscription'.
This is sufficient for *generalizing* science, but not for *generating* design.

The language is a limited means of communication that can cover certain *truths* and untruths, but by no means all *possibilities*. It *suggests* that it can cover any imagination, but it does not have that misleading completeness. Your wild ideas became literate, linear, focused and limited, as soon as you learned to read and write.[a]
What you could not speak about, you had to remain silent about.[b]

However, even great advocates of logic, such as Pythagoras, Newton, and Wittgenstein, hid a mystical contraband beneath their language-bound logic.

The meaning of words contains unspoken suppositions, images for which there are not always words. For example, the words 'mass', 'force' and 'acceleration' suppose indefinable circular assumptions, but in mechanics their *relations* are definable and usable in practice.

This made some believe that relations are more real than objects, but that moves the problem into the definition of the word 'relation' itself.
A 'relation' supposes different objects, masses, substances, variables or whatever you want to call them, *between* which such a relationship 'exists'.

That therefore supposes, first of all, that these objects differ.
Even in order to conclude an *equality* between objects, these must be *different* objects.
Science is looking for similarities in order to be able to generalize them in 'laws', but designing is making a difference, otherwise it is copying.

Difference itself is not a 'relation' supposing objects; an object supposes a difference.[c]
In this study to a 'practical' sequence of suppositions preceding each representation, not 'equal' and 'being' are taken as the starting point[d], but 'difference' and 'making'.

New ideas cannot be derived from 'equal equalities' but from 'different differences' (among which equality) they can.
This has consequences for the use of words such as 'relationship', 'property' ('attribute', 'characteristic') and 'category'.

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a Kraak(2006)Homo loquens en scribens Over natuur en cultuur bij de taal(Amsterdam)University Press
b Free to Wittgenstein(1922)Tractatus logico-philosophicus Logisch-philosophische Abhandlung(Frankfurt am Main1963)Suhrkamp p115
c Connections and separations are relationships. A difference, however, may exist on itself, independent from what exists on both sides.
d That happened in previous attempts, such as the 'Konstitutionstheorie' of Carnap(1928)Der logische Aufbau der Welt(Hamburg 1961)Felix Meiner §108 p150, strongly oriented on Russell(1903) The Principles of Mathematics(London 1996)Norton. Russel §167 p179 also uses 'difference in the sense of dissimilarity'. 'Difference' is then derived from equality. In the negation 'dis', however, 'difference' is assumed.

§ 2 DESIGN SUPPOSES POSSIBILITY

DESIGNING DIFFERS FROM *USING* DESIGNS

The role of designers and their inventions in world history is overshadowed by their economic, cultural and administrative *effect* after realisation. Their users, applications and effects fill the history books. Only footnotes refer to the designers and their designs as one-off events, mutations that do not lend themselves to generalization.

My Dutch countrymen often forgot the inventions with global effect from our own country and their contribution to the stormy development of science since the Renaissance, even though they now determine our daily lives.

This development has been made possible by *designs* such as the printing press[a], the telescope, the microscope[b], the pendulum clock[c], the steam engine, the Otto motor, the transistor, the radio telescope[d], the particle accelerators[e].

Scientific hypotheses and methods are also *invented* instruments that subsequently make discoveries possible. The mathematical notation, the use of coordinates, the empirical cycle, the theories, the experiments with which they have been tested, the mechanics, the thermodynamics, the theory of relativity, the atom model, or quantum theory are designed, separately from their later applications.

Yes, science itself is not a natural phenomenon that has been discovered (found somewhere), but a human design, an instrument for reliable and valid truth-finding.[f] However, *designing* an instrument, requires other skills than its *use*.

MAKING POSSIBLE SUPPOSES CREATING CONDITIONS

A house is not designed to *cause* a household, but to make different kinds of households *possible*. It creates conditions for a household but it does not determine a specific kind of household.

The difference between *cause* and *condition* is crucial for the distinction between empirical research and design study.
A cause is a condition for an event, but not every condition is also its cause.
By 'condition' I do not mean primarily the logical condition with a *truth* value ('if ...

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a Germans, Dutch and Flemish people are still fighting for the honor of having been the first with their inventors Johannes Gutenberg, Laurens Janszoon Coster or Dirk Martens.

b The microscope (1595) and telescope (1609) were invented in Middelburg by Sacharias Jansen. By the telescope, Lipperhey and Metius are also called Dutch inventors. With a telescope from Middelburg, Galileo learned from planetary orbits to understand valleys to refute Aristotle's centuries-long suppositions. With the microscope Van Leeuwenhoek opened up microbiology

c A patent from Christiaan Huygens, who also introduced the use of mathematical formulas in physics.

d Originating from an important discovery by the Utrecht astronomer Henk van de Hulst in 1944, when he still studied in the WWII isolation, undisturbed by the stray light of publications, with Marcel Minnaert in the Utrecht Observatory. On the roof, thanks to the obscuration enforced by the occupying forces, the students were able to see for the first time the stars that were previously hidden by the stray light. Thanks to his work, the Galaxy was charted with radio telescopy after WWII.

e An instrument to which the Delft engineer Van der Meer made contributions with which he shared a Nobel Prize in 1984. This demonstrated the particles previously predicted by the Utrecht Nobel Prize winner 't Hooft.

f How design and scientific research can go hand in hand and have a direct effect on history is perhaps proven most impressively by Flemish-Dutch genius Simon Stevin. He wrote out of conviction only in Dutch, so that his ground-breaking inventions and discoveries for foreign countries remained hidden for a long time. They gave the young Republic of his pupil Prince Maurits a decisive lead in many areas and it would not surprise me if we had passed the 80-year war by such a free-thinking élan. These were fairly underestimated innovations in mathematics, mechanics, hydrostatics, astronomy, geography, maritime science, technology, martial arts, accounting, architecture, music, sociology, logic and the Dutch language. Dijksterhuis (1943) Simon Stevin (The Hague) Martinus Nijhoff, needs 600 pages to do justice to him.

then', 'then ... if' or 'then and only then ... if'), but a 'practical condition' with a *possibility* value: not 'if x then y is *true*', but 'if x then y is *possible*'.

The 'practical condition' does not conclude, does not generalize, but it generates, specifies, makes feasible in a constructive series. I will use the term 'condition' in this sense, unless otherwise stated, or if the context shows otherwise.

Suppositions are conditions for imagination.
You can imagine something only on the basis of all sorts of hidden, self-evident or learned pre-suppositions. There are, however, also assumptions[a] *limiting* that imagination and thus blocking our design skills.

Design does not only seek truth or probability
A design is not a prediction. Yet the designs themselves, including the inventions that have made discoveries possible, are generally regarded as the scientific results of seeking truth or probability. *That is a false assumption.*

The printing press exposed opinions to broad criticism, a condition for science.
The telescope brought Galileo new understanding of planets, their valleys and orbits.
With his microscope Van Leeuwenhoek gave the go-ahead for microbiology.
The pendulum clock of Christiaan Huygens made exact time measurement possible.
Numerous electrical experiments with often useless instruments preceded the theory.

Thermodynamics came a century after the steam engine. Shortly thereafter followed the combustion engine of Nicolaus August Otto[b], a grocery without a science degree, whose invention lives on today. The theory of relativity was designed by an inventor of refrigerators[c], working on a patent office, before its validity has been proven. Design requires something else than empirical proving its reliability afterwards.

A theory is *designed* once and tested repeatedly with *designed* instruments.
Previous hypotheses are not discovered, but *designed* as a possibility. Their 'truth' (operation) is 'discovered' by empirical research. The hypothesis gives direction to the research question. The assessment, preferably by others and in any case with an attitude other than that of inventors, requires verifiable reliability and validity.

The inventors have undoubtedly made *use* of previous scientific discoveries and results, but designing is more than just use.
Scientific research is part of that more comprehensive, typically human imagination that we call designing, and not the reverse.

Truth-finding leads to fixed, broadly shared assumptions (paradigms) that can even stand in the way of that bold ability to imagine unlikely, *improbable* possibilities.
Designers must dare to disregard standard suppositions, simply forget them or replace

a I do not yet use the word 'supposition' here. I reserve this for conditions making our imagination possible as underlying stones in a construction. An 'assumption' than is an arbitrary, non based statement 'taken for true', in a logical reasoning or taken as (im)possible in a design.
b https://nl.wikipedia.org/wiki/Nikolaus_Otto
c Schils(2008)Einsteins koelkast(Diemen)Veen Magazines

them with others, to come up with something new.
Some call it 'reframing', but it is not just about the framework.

An empirical method does not teach designing
Everyone looks for opportunities in daily life, *designs* them before they are realized and used. Searching for truth is a laborious part of this, but *possibility* includes more than truth. You may *know* what is already there. You have to *make* which is not. You can know, but you know not can. There are widely accepted methods for 'knowing', but 'being able' still should be practiced by doing.

Some designers have made their job of looking for new possibilities.
How did they learn that? In the design training of my university we followed lectures of researchers and designers in the morning. This was mostly about existing designs and techniques, but art history does not make artists yet. In the afternoon we made designs ourselves, under the supervision of design teachers in studios.

In that other world of design studios little reminded of the lectures in the morning. This medieval scholastic sequence ('lectiones' in the morning, 'disputationes' in the afternoon) can better be reversed in design education. Designing raises questions. Answers do not produce designs. The design teachers each told their own story. It even seems as if there are as many design methods as there are designers.[a]

The research teachers were more in unison. They were empowered by the empirically trained specialists with whom the teaching team was expanded to make the program more 'scientific'. This way, it could happen that design is now mainly taught according to the lines of empirically inductive and deductive research (problem definition, objective, etc.).[b] That is also expected from a university. It just does not work.[c]

Designing is more than induction and deduction.
It is also more than abduction (***Fig. 50*** p107).[d]
There is much literature about existing designs, much less about how to make them.

We can know, but we apparently cannot 'know' the prior 'can'.
How then should you *learn* to design?
In order to unlock possibilities you probably also have to *un*learn things.

Design crashes in empiricism
My doubt goes beyond a design training that crashes in empiricism.
Design study requires an imagination that goes beyond the mass of circulating ready-made images via various media. Such representations do not train your own imagination. They discourage it.

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a S Jong; Voordt(2002)Ways to study and research urban, architectural and technical design(Delft)DUP p20 http://www.taekemdejong.nl/Publications/2002/Jong(2002)WaysToStudy(Delft).pdf

b Simon(1969)The Sciences Of The Artificial (CambridgeMass1982)MITPress p36 'Heuristic search... is in fact the principal engine for human problem solving ...'.

c Winy Maas outlines the limitation of the Delft architectural education as "... coming up with solutions to problems …”. Hannema (2017) Land van Maas (Volkskrant) 1014

d Among others defended by Dorst (2013) Academic design (Eindhoven) TUE Inaugural address. It is impossible, however, as a designer of *possibilities* to derive a methodological justification from the *truth* logic. (See Fig. 3 p8 and note a on p44)

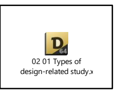
Our representations have already been uniformed by the linear language in which we communicate and generalize, the logic by which we are convinced, the cliched learned prejudices and collective errors that we do not know because everyone has them. There are many learned and forced assumptions that we are not aware of.

They can, as seemingly self-evident paradigms, imprison and stifle our imagination for a long time. They then stand in the way of developing design *and* science. Which assumptions do so? A fish does not 'know' what water is, until it is removed into the air. It thus comes into a different world in which it can no longer live.

For humans, on the other hand, it could mean a rescue. Which assumptions have kept us under water for such a long time, not susceptible to Prometheus' fire?
How can we get air and land on the vast terrain of improbable opportunities?
The unlikely nature and chemistry of living organisms (chapter 9 p214) is at the forefront of showing possibilities that no human being could have imagined before.[a]

DESIGN RELATED STUDY SUPPOSES OBJECT AND CONTEXT, DETERMINED OR NOT

You can distinguish 4 types of design related study.[b]
The distinction between 'research' and more ecompassing 'study' makes sense.
If the **object** is already designed, and thus known in detail, then you may 'research' it.
If the object is still variable, then it is 'study' (the columns in ***Fig. 2***).
There are two variants of both (the rows in ***Fig. 2***).



The physical, technical, economic, cultural and governance **context**[c] also can be determined ('known'), or still variable.
If the object *and* the context are known, then it is 'design *research*', a kind of (art) history.
If, however, it concerns known objects in *different* contexts, then it is a more professional 'typological *research*'.

		OBJECT *Determined*	*Variable*
CONTEXT	*Determined*	Design research	Design study
	Variable	Typological research	Study by design

Fig. 2 Types of design related study

Both are characterized by an empirical method, but this method is inadequate if the object is still variable. In an ordinary design assignment the *context* is known, but the *object* varies in the head of the designer ('design *study*').

Important inventions, however, have also been made where even the context of the variable object has been not yet determined. The inventor had no idea in which context his object could ever be used ('*study* by design').[d] I have in mind the electrical experiments of the 18th century. Nobody had a valid idea of the object 'electricity' and of the countless contexts in which it would prove its use in the centuries thereafter.

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a They therefore form a growing source of inspiration for the technology ('biomimetics' or 'biomimicry'). See for example Lems (2009) Thermodynamic explorations into sustainable energy conversion (Delft) TUDthesis.
b Jong, Voordt eds (2002)Ways to study and research urban, architectural and technical design (Delft) DUP Science p20
c 'Context' refers in principle to a textual environment, but this concept will be used in a more general sense of 'environment'.
d Hintikka(1985)Logic of discovery and logic of discourse(New York)Plenum Press is about answering a question, solving a problem and not about making a design.

1 SCIENCE SUPPOSES DESIGN, NOT THE REVERSE

USELESS SUPPOSITIONS BLOCK DESIGN

The summer of science is over

Since the miracle of Renaissance until the first half of the 20th century, inventions and discoveries have eliminated many blocking and false assumptions.
The design called 'science' was an instrument to unmask false assumptions, to make us immune to them and to shake up our imagination.

That role seems to be played out, although there are exceptions, such as the continuing stream of fascinating biological discoveries and medical inventions.
These dominate the science supplements in the papers.

Fantasy and games sell better than less directly 'relevant' scientific discoveries.
The technique provides commercially interesting improvements (or combinations) of already existing and long-standing inventions.[a]

Direct socially relevant outcomes of scientific research are context dependent.
They are therefore immediately scientifically questioned in other contexts.
This undermines public confidence in the current truth-finding.

What is universally generalizable is already largely generalized.
A local *average* is still commercially interesting, but the excessively distant remainder of the *singular*, the *unique*, is not supported by statistical reliability.
What remains, are special cases in which many uncertain context variables play a role.

'New inventions' now combine and miniaturize mainly inventions from the last century (internet, iPhone). That is rather combination, management, than design.
Futile variants or updates become a good selling hype. Groundbreaking design requires greater deviations, daring to evade conventional suppositions.

There are more myths in the world now than in the time of Thales of Miletus 600 BC.
They grow like mushrooms. Summer is over.
Their commercial roots reach into science. You should go through her disciplines one by one to see where their innovative potential has been affected.

Design instructions may block imagination

In design practice, many regulations apply, developed by empirical research.
"Wherever there is the possibility of measuring performance, there is also the opportunity to legislate."[b] They may prevent errors from past contexts with undesirable consequences, but Lawson(1990)p53 refers to desastrous failures.

The few *measurable* performance factors pull countless others out of context.
Empirical 'ceteris paribus' deprives the view on opportunities in other contexts.
To dictate a designer more than what years of education, extended and relativated by experience, have already yielded, is dangerous. It hides improbable possibilities.

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a All great inventions have been made by now: Noort(2016)Gordon: Alle grote uitvindingen zijn inmiddels wel gedaan(NRC)0319
b Lawson(1990)How designers think, the design process demystified(Oxford)Butterworth Architecture p54

In design education regulations of 'prescriptive knowledge' may play the role of tacit assumptions and prematurely block imagination.

A great challenge for design students would be: analyze an existing facility or existing tool, make its assumptions explicit, omit at least one, design something similar without that assumption(s).

Knowing belongs to a modality different from designing.
Design and technology require imagination and skill.
That imagination is captured by hidden assumptions no longer under discussion.

Generating is at odds with generalizing; 'ceteris paribus' is seldom right.
There are circumstances in which the general does not apply.
You should not let go exceptional opportunities. Avoiding risks is risky itself.

Regulations are not true or false. They belong to the modality of the desirable.
Know-that belongs to the modality of what is true, probable, untrue or unlikely.[a]
Know-how is dualistic. As far as it concerns routines with a fixed result, it is a historical science of existing recipes.
From history, however, you can often learn better what to avoid than what to do.

The current administrative, cultural, economic, technical, ecological and physical context is decisive for the success of such routines.

Know-how includes more than know-that and routine.
Insofar as know-how does not involve routines, it is part of the exploration of the third modality: *possibility*. Exploring the potential within a given context, you first have to understand that *context* and sometimes thoroughly analyze it.[b]

Design should avoid some usual scientific suppositions

There is no doubt that designers *use* the results of empirical research intensively, but their own work differs fundamentally from that of their *suppliers*.
A researcher searches for truth, probability and sometimes desirability.
A designer looks for possibilities, as far as they are *not* yet true or probable, and even not necessarily desired consciously by anyone.

A designer and particularly a designer of multifunctional facilities,
1 cannot isolate a singular problem from a field of problems that can be solved together;
2 cannot isolate a singular goal from a field of diverging objectives for diverging interests;

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a The fact that 'truth' itself is a modality is contrary to prevailing views in modal logic (p49). Modal logic would take a completely different form if truth (according to Fig. 3 p12) would be taken as a limited and limiting part of possibility.
In the current 'alethic' modal logic the truth logic is valid in all possible worlds and thus a limitation of possibilities.
Of these, the laws of nature are a ('nomological') part and also universally 'necessary'. However, they are both part of our language ('analytical possibility') and our sense of existence ('metaphysical possibility'), which in the alethic vision are also included as necessary in all possible worlds.
The 'possibility' that I hold here concerns (more broadly that alethically) the possible worlds in which 'actions' are possible, changes that can be set in motion by someone or something. I call that 'practical' modality with 'practical' conditions.

b Jong(2007)Operational context analysis as a part of design related study and research(Zoetermeer)WSEAS EEED '07

3 cannot work only in a goal-oriented way, but also in a means-oriented way (looks at what is possible by what is available);
4 cannot formulate a research object before it has been designed, before the work is done: that object varies in thought and gradually develops from vague to concrete by looking, sketching, calculating, reading and writing;
5 has only a context with many variables on different levels of scale as its starting point;
6 brings together explicit and unspoken administrative, cultural, economic, technical, ecological and physical problems, objectives and means from this context in a concept, a representation or proposal in which more stakeholders can project and weigh their own (sometimes unforeseen and unspoken) objectives;
7 produces a concept with a general hypothesis that is hardly worth mentioning: 'This will work';
8 therefore has starting points different from a clear object definition, problem definition, objective, hypothesis, a representation of how facts must be collected, arranged and related to each other;
9 has many methods to arrive at a concept: from material, form, structure, function or intention, in all conceivable orders and intensities of this series;
10 has more references than written text: images, forms, types, models and other concepts;
11 uses notions that cannot be generalized in everyday language as words;
12 differentiates meanings per scale level and per unique context.

This does not correspond to the current assumptions of (conditions for) valid and reliable science. How, for example, do you start without a clear problem and objective, even without a clear object of research?

The beginning is before all that. Common assumptions deserve doubt.
What does a problem, a goal, an object itself actually mean?
A target *field* aims at solving different problems simultanously, if at least (with the means that language and drawing offer us) a possibility of solution is conceivable.

Problem signaling, however, includes an analysis of *missing* conditions.
As a result, the *coherence* of problems becomes design-relevant.
The target field stands out as a system of realizable conditions, hypotheses in which different goals even seem to have been realized already in one solution.

A designer cannot keep problem, goal, means and hypothesis separate as in classical scientific research. More or less in the order of the above 12 points I will give below my preliminary analysis of the usual assumptions that play a role here.
They then act as a problem field for the following chapters.

PROBLEM AND TARGET FIELD SUPPOSE MODAL SUBSETS[a]

Any true or at least probable statement is by definition possible, but not vice versa.
The probable futures are a subset of the practically possible futures (***Fig. 3***).
There are also improbable possibilities. Because they are not true or probable, you cannot predict them causally (from known cause-effect relationships).
You have to design them: outline *conditions* to make something possible.

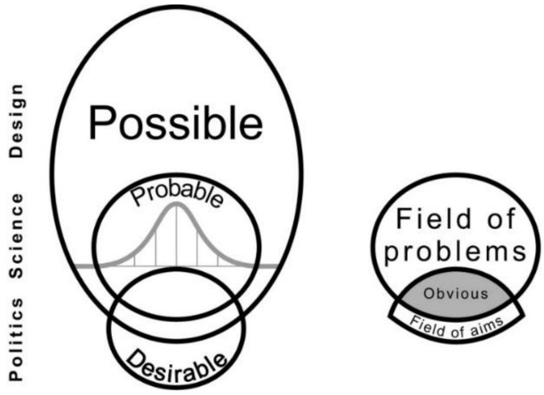

Fig. 3 The modal place of problem field and target field

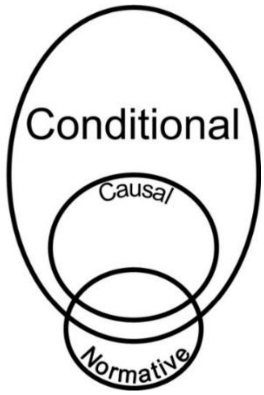

Fig. 4 Modally limited thinking

Thinking about conditions of opportunity differs from causal thinking (***Fig. 4***).
A house does not *cause* a household, it makes different households *possible*.
Deciding whether you *want* a household also requires a different way of thinking ('modality'). Many desirable futures are not practically possible. Forget about them.

Other desirable futures are probable. Do not attempt anything. It will probably happen also without your effort (many people are doing so without effect).
Do not act until there are probable futures that you do not want (problems).
If there are also improbable possibilities that you want (field of aims, ***Fig. 3***), then design them.

Designers look for improbable opportunities.
If those possibilities were likely, then they would not be designs, but empirical predictions. Moreover, they are looking for something other than what is already there, making a difference. Otherwise, designs would be copies.

The old discussion if design is a science, and therefore can be taught at a university, is easily solved if you accept that science itself is a design, not the reverse.
Many will not accept such a conclusion.

a Cited with own changes from Jong(2012)Diversifying environments through design(Delft)TUD second thesis p16

§ 3 VERBAL LANGUAGE CREATES PARADOXES

THE CONCEPT OF 'OBJECT' IS PARADOXICAL BY DIRECTION AND SCALE

'Object' is not the self-evident concept that most authors take for granted.[a]

It has tacit suppositions. As a newborn (still without references) you will probably not immediately see separate 'objects' in the multiplicity of impressions that you get 'pre-cast' (ob-ject is literally pre-cast). This discernment must be *learned* as a representation in a long-term repeated sequence of tactile and visual impressions.

This well observable process in babies sheds some light on assumptions of which we are no longer aware of as adults (chapter 3 p48).
An 'object' in our first phase of life is the part of an incoming image that separates itself from the rest ('everything except' or 'not' the object), by 'parallax exercises'.

When you move, you see something in the foreground appear more quickly than the background ('parallax'), but when you follow that object with your eyes, the background moves in relation to that object ('object constancy').
That active separation (loosening, dis-connection, dis-traction, abs-traction) supposes the observation of permanent differences in all directions despite motion.

This also sets the foundation for the conjunction 'not' (everything *except* the object). 'Not' leaves everything except the object undetermined.
The 'attention' focuses on an object ('focus'). Loosing an object that is no longer perceived (eg learned with the game 'peek-a-boo'), requires a stack of abstractions that gradually under-lie (are sub-posed in) concrete impressions and experience.

Parallax, however, does not help anymore in the recognizing of a constellation of stars such as Orion, based on an arbitrary traditional outline of the figure.
Many other outlines would have been possible.
Such arbitrary outlines are taught by culture and become sup-posed in the observation.

The abstraction technique for deriving object constancy is repeated in non-actual, (often taught) internal representations (re-presented, brought back to present).
Three paradoxes appear when distinguishing objects:
a paradox of perpendicularity, an inside-outside paradox, and a paradox of scale.

'DIFFERENCE' IS PERPENDICULAR TO EQUALITY (PERPENDICULARITY PARADOX)

An omnidirectional enclosing sharp outline of differences between an 2D object and its environment (the difference between 'yes' and 'no') does not take up any space.
Each difference in the 2D surface has a direction. Perpendicular to that direction there must be less difference (some equality, similarity) in order to see the difference.

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a Kant (1781) Critik der reinen Vernunft (Riga) Hartknoch, has said wise things, but in the course of his argument he tacitly passes a growing number of suppositions that I do not share. He laid down his foundation at least on the tenth floor. He does not mention underlying floors (the suppositions). As a result, he needs hundreds of pages of scaffolding to keep his building upright on skinny pillars.
One set of assumptions is tacitly stored in the term 'object'. Kant takes that concept everywhere for granted (as many do), but it is not. Recognition of an object and the detachment of that object from an environment full of differences, is the result of a long lasting learning process (p28).
Other unspoken suppositions at Kant are hidden in concepts such as the indivisible individual, substance, logic, knowledge, the concept of 'concept' itself, and of course also in its categories and judgments (see p92).

The kind of difference may be direction-dependent, as long as there is a continuous difference (last picture of ***Fig. 5***).

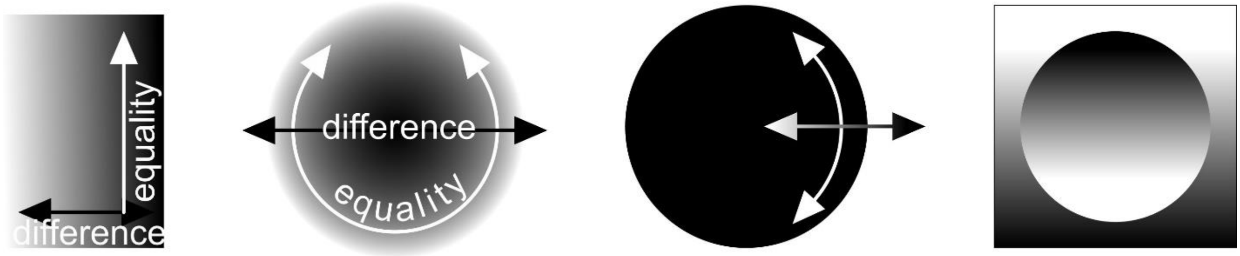

Fig. 5 A perpendicularity paradox in vague and sharp object boundaries

This perpendicularity paradox applies also in space taking vague boundaries.
It is immediately clear from a 2D drawing, but in a linear language this perpendicular relationship can lead to contradictions. 'The bridge is open' says the skipper.
That is at odds with what the motorist reports. Who is lying?

'INTERIOR' SUPPOSES A CONTRARY EXTERIOR (INSIDE-OUTSIDE PARADOX)

There is also an inside-outside paradox, which produces a seeming disagreement.
A ball is hollow, seen from the inside, but convex from the outside.
The impression of an object changes drastically coming out, but entering, the difference itself remains the same in the opposite direction (symmetry).
A linear verbal representation may distinguish a difference 'from light to dark' and its reverse, but an *image* does not prescribe a direction to see the same difference.

Going out from home is like a birth.
To step out is called 'ex-sistere' in Latin and 'ek-stasis' in Greek. Existence and ecstasy do have the same origin, the very experience of this paradox.

Russel's and Descartes' paradoxes are inside-outside paradoxes

'I lie' is a double message.[a] If I tell an *untruth*, then it is still *true* that I am lying.
One message is about the action of my lying (true), the other is the lie content (false).
One message ('meta-language') is about the outside, the other is about the inside.
A child knows such a thing, building huts or tents and experiencing the inside-out opposition of viewing direction as coming out and entering (eg light-dark).

Something similar happens when we think *about* 'thinking' (philosophy, psychology).
The second 'thinking' is the content, the first supposes what we say *about* that 'thing'.
That applies even when we talk about language, the exchange of thoughts.
We then must be prepared for apparent contradictions (paradoxes).
When we say something 'about', it suggests that we look at it from the outside or 'from above' ('at right angles' to the area being looked at).

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a An example of Russell's paradox that a set cannot contain itself as an element. Russell(1903)The Principles of Mathematics(Cambridge)University Press p101 WWW2016 http://fair-use.org/bertrand-russell/the-principles-of-mathematics/index

Whether that content is true or false, *that* I think about it is true (the 'cogito' of Descartes).[a] So, you can tell truths about truths, truths about falsehoods, falsehoods about truths and untruths about falsehoods.

You are outside the past

Could the past be 'true'? If you talk *about* an impression, it is already a thing of the past, no longer accessible to your own action, no longer 'actual'.
Even a football reporter can only tell what happens if it already has happened.

We are only convinced of that unreal, not actual, past, if more sources tell the same. Those stories cannot be chequed or tested.
They are no longer accessible for a controlling *action*.

Moreover, every memory is based on a flat image[b]. In spite of all kinds of connected additions and associations, little remains. The sequence of memories as a stack of photos is then 'perpendicular' to the images themselves. The three spatial dimensions are 'perpendicular' to each other, perhaps the fourth (time) too.

A JUDGEMENT MAY TURN TO ITS OPPOSITE BY CHANGE OF SCALE (SCALE PARADOX)

If you observe the pattern in ***Fig. 6*** in detail, then you only see differences: every black dot has a white one in its surroundings and the reverse.
At a distance, however, you see equality.

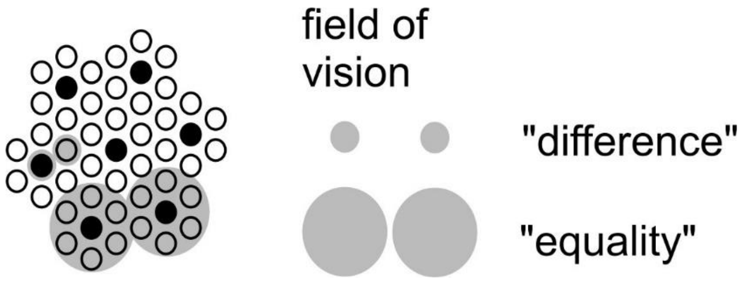

Fig. 6 Scale paradox

The judgment 'difference' or 'equality' can therefore be reversed already at a linear scale difference factor of 3. That is a minimum and only a possibility, but there are 10 decimals between the size of a grain of sand and of the earth.

These are at least 20 factors 3. So, in theory there are more than 20 possibilities to disagree, while you actually agree, if you keep an eye on the scale of the claim.

The scale paradox leads to senseless differences of opinion.
A street with all different buildings looks like other streets with such an arbitrary mixture of buildings. Paradoxically, some *equality* between buildings in each street on its own is required to distinguish the *difference* from other streets.

a The latin background of cogitare (co-agitare, thinking) is interesting: 'repeatedly acting with'. For the Romans thinking was apparently acting parallel to reality. I will indicate it further with 'co-action'. Inventing or designing would then be counter-acting to reality. Designing is then indeed 'ejecting' from an existing reality.

b A memory is also largely coming from the flat retina or flat skin. The third dimension must then be a construction with (possibly remembered) experience of our own movements (motor skills).

An urban planner who complains about the characterless uniformity of the streets will therefore disagree with the architect who enthusiastically praises the different character of each home individually.

Meaning rests on suppositions.
With other scale suppositions, the meaning can change.
If your conversation partner is arguing with *two* reversals above the scale you have in mind, then you can even agree with each other while you mean something different.[a]

With the insight of the scale paradox, I do not immediately have to assume mystical forces like an 'invisible hand' of Adam Smith in the economy or the 'self-organization' of 'complex systems' that astound physicists when they observe sudden order ('synergy') in microscopical chaos ('emergence', a 'phase transition' such as freezing, p204) under certain macroscopical conditions.

The scale paradox does, however, give rise to the relevant question what 'disorder' and 'order' exactly mean.[b]
In physics, 'disorder' ('entropy' S) is the probability of a spatial distribution (p194).
An orderly state (all gas concentrated in a corner) then is improbable (low entropy).
In computer science, the amount of information which is at least necessary to describe a system (H, expressed in 'bits' p197) is intended analogously.

Disorder requires more bits for representation than order.
If in a larger radius one or another repetition appears, then you can suddenly describe the system with fewer bits ('information compression').

Both kinds of 'order' are *different* from 'organization' between different organisms or different organs with different functions. In ecology just *this* is concerned as a valuable, less chaotic increase in the information content of a system.
A phase transition to less biodiversity may mean more order, but less organization.

An ecosystem with few species is easier to describe with mathematical addition and multiplication than an ecosystem with many species and many different mutual relationships. Then, there is plenty of reason to shift the attention to rare organisms and unlikely situations. That is also typically the focus of designers.

Self-organization then is a misleading term, feeding the risky confidence of laissez-faire liberals. I would prefer to speak of repetition, regularity or coordination that can occur in large numbers of particles, individuals or waves as a sort of resonance in a laser, or in a 'wave' in a football stadium (simply because you do not get space enough in the opposite direction). It is questionable whether 'self-organization' is desirable, if it means extinction of deviating categories. 'Synergy' in the ecological sense of symbiosis with mutual benefit between different species is just the opposite.

a This also applies to the exchange of cause and effect on different time scales. See for example: Jong(1998)Wat eerst: wonen, water, wegen of welvaart In Angremond Editor Watertovenaars Delftse ideeën voor nog 200 jaar Rijkswaterstaat pp 42-52(Delft)

b Alexander(2002)The nature of order 1,2,3,4(Berkeley)Center for environmental structure needs 4 volumes to explain the concept of order. Kaufmann(1993)The origins of order(Oxford) University Press needs more than 1000 pages.

1 SCIENCE SUPPOSES DESIGN, NOT THE REVERSE

'FUNCTION' HIDES SUPPOSITIONS OF SCALE, DIRECTION, CONTEXT AND STRUCTURE

Any 'function' supposes a level of scale

A good example of change of meaning through the scales is the concept of 'function', so often used in science and designing.[a] This change of meaning is already detectable linearly by a factor of ca. 3 (around 10 in area), be it often unnoticed.

What is the function of a brick (nominal radius[b] R=10cm), a window (R=>30cm, a door (R=1m), a room (R=3m), a house (R=10m), a building complex (R=30m), an 'ensemble' (R=100m), a neighborhood (R=300m), a district (R=1km), a city (R=3km), a conurbation (R=10km), a metropolis (R=30km), a region (R=100km), a country (R=300km), a continent (R=1000km), yes, what is the function of the world?

Any 'intention' supposes functions and therefore a level of scale

The term 'function' is often understood 'teleologically' as purpose.
I can, however, imagine unintended functions, but I cannot imagine an intention without (intended) functions.
A design has more unintended effects than intended. If intention *supposes* function, and 'function' is scale-sensitive, then 'intention' is also scale-sensitive.

Politics concerns scale-sensitive intentions.

If you define 'politics' as looking for an answer to the question 'What should we do *for ourselves* and what should we do *together*?', then scale-articulation is necessary to distinguish intentions.

What do we do together at the level of a house, building complex, ensemble, neighborhood, district, city (municipality), regionally, nationally, continentally or internationally and what are we going to decentralize again?

A political party assumes scale levels in its program where 'for themselves' and 'together' acquire different meanings.

The meaning of 'function' changes from physics to humanities

Administrative, cultural, economic, technical, ecological and physical *functions* differ substantially in meaning. Moreover, at every level of scale any of these functions can get a different meaning and priority or dominance.

'Function' hides an inside-outside paradox

If you define 'function' as operation or working, then you should distinguish an inward and an outward function. A house has an inward function for its residents, but also an outward for the neighborhood, the city and so on.
A car is *constructed* and *used*. Its internal structure should fulfill many functions of

a That function concept for the design is central, for example in Kroes(2006)The dual nature of technical artefacts(Studies in History and Philosophy of Science)0301 Vol 37 nr 1. In this, hardly any attention is paid to the scale on which people can speak of 'function'

b With this 'nominal radius' R is meant here an element from a series of dimension *names* that each do not exactly represent the radius of the circumscribed circle, but a radius that lies between the previous R and following in that series. A small r then concerns the inscribed circle (resolution).

transforming energies, but it has also an external function for a family, a business, a city and so on. A ball is hollow to function light and elastic and convex for playing.

'Function' supposes structure

I cannot imagine a function without an external *structure* (a set of connections and separations) within which it operates (eg a manager supposes an organization, an aeroplane supposes customers, airports and free air).

A function supposes, however, also an internal *structure* (construction) through which the facility can operate at all.
On its turn, 'structure' supposes a dispersion in space (and time), a 'form(ation)'.
'Function' therefore also supposes 'form'.

Combination of functions saves space, specialization saves time.

This may be a bold statement, but it is an actual dilemma in many designs. The claim supposes a complementarity of space and time (***Fig. 9*** p27). Separation of functions on a large scale, however, may also require traffic time, diminishing the time profit.

Mathematical functions reduce 'function' to operations on numbers

This limited use of the concept 'function' is elaborated in chapter 7 p128

Any design is multifunctional

In order to design an object, you can start with the function ('functionalism').
That is a widely used methodical goal-oriented start.
There is, however, rarely *one* 'monofunctional' function or operation at issue.
For example, there are always financial consequences and there are often more stakeholders with different intentions (built upon the different suppositions mentioned above) enabling to use different functions of the same facility.

This way, each design is in principle multi-functional.
A program of requirements is an enumeration of desired functions, but that is seldom complete, if you take every scale, direction, context and structure into account.
Some functions are so obvious that they are not in the program for a home.
The designer also often finds function possibilities that no one has anticipated, such as a door in which you can also sit[a].

If the overview of all these functions in the target field is no longer guiding because of the multiplicity, a designer can also start in a resource-oriented (means-directed) way with available contexts, materials, possible forms or structures.

A sketch of shapes or structures sometimes may suddenly offer space to all requested functions in unexpected combinations and still add functions that fulfill unspoken wishes.[b] The program of the stakeholders can change.[c]

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a An example from the lectures of Aldo van Eyck in the 70s at the TUDelft about the huts of the Dogon people in Mali.
b Designers of a new large urban district (I will not name the location) stated that they had not studied the piles of municipal files with requirements and wishes, when they surprised the stakeholders with a design, that almost all requirements and wishes had been met.
c Jong;Voordt(2002)Ways to study and research urban, architectural and technical design(Delft)DUP p271.
http://www.taekemdejong.nl/Publications/2002/29 PROGRAMMING OF BUILDINGS from Jong(2002)WaysToStudy(Delft).pdf

2. THIS STUDY REDUCES BLOCKING SUPPOSITIONS

§ 4 IMAGINATION IS BUILT ON PRACTICAL CONDITIONS

CONDITIONS OF DESIGN ARE A SEQUENCE OF SUPPOSITIONS

In design, content, form, structure, function and intention, suppose each other in a conditional sequence.

There is no intention without a vague or specific representation of some function, no function without an internal or external structure by which or in which it can function, no structure without a form (state of dispersion) in which it 'takes place' in space, and no form without material ('content') that can take this form.

This conditional *sequence* does not yet play a significant role in the the *design process* itself.[a] It comes to the fore by *realization*.

A designer sketching forms is still free to alternate the focus arbitrarily to the content, form, structure, functions or intentions. A designer then alternately adresses different skills, providing new perspectives and inspiration. The focus changes can follow each other quickly or slowly. That is why there are as many design methods[b] as designers.

The conditional sequence, however, is important for realization.
In that sense a designer can anticipate it in the design process in order to shift focus once again. At the end of the design process it is a checklist to check the designed object for its practical-conditional coherence ('evaluation' afterwards).

A similar conditional set of possibility conditions exists for the *context* in which the designer is placed with a not yet developed object at the start of a design process. There are physical, biological, technical, economic, cultural and administrative conditions that suppose each other in this order.

You cannot imagine a management or governance if there is no culture (authority, language, motivation) that carries it.
You cannot imagine a culture that can maintain itself without an economic base, no economy without the existing technology that makes it possible, and so on.

The estimation of such a context and the utilization of its possibilities requires again different specific skills from a designer, prior to those required for the determination of content, form, structure, function and intention in the design process itself.

Both object and context of design suppose levels of scale and different modalities.

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a Jong, Taeke M. de (1988) Inleiding Milieuplanning (Delft) TUDelft Intreerede (inaugural speech)
b 'Meta-hodos' is Greek for 'the way along'.

DESIGN SUPPOSES MODALITIES, LEVELS OF SCALE, LAYERS OF CONTEXT AND OBJECT

So, I assume four dimensions tacitly supposed in any design (or imagination):

modality	levels of scale		context layers	object layers
True	…		Governance	Intention
⇒	?		⇓	⇓
Probable	10m	C	Culture	Function
⇒	?		⇓	⇓
Possible	3m		Economy	Structure
⇒	?		⇓	⇓
Imaginable	1m		Technique	Form
∧	?	B	⇓	⇓
Desirable	…		Biotics	Content
			⇓	
		A	Abiotics	

⇒ means 'implies' ⇓ means 'supposes' ∧ means 'overlapped by'

Fig. 7 Design dimensions: modality, level of scale, context and object

A higher layer *supposes* an underlying layer symbolized as ⇓.
In chapter 6 p114 I wil discuss its relation to the logical implication ⇒ (if…then).

Suppositions can be summarized (ABC) or divided in more elementary components (technique), without losing the conditionality (the sequence is 'transitive').
Fig. 13 on p37 will divide them in a more general, extended constitution.

For the modalities in ***Fig. 7*** '**imaginable**' is a necessary basis, '**desirable'** overlaps.

In ***Fig. 3*** on p15 the imaginable is not bounded, because then you should be able to imagine the other side of the boundary, the 'unimaginable'.[a] The imaginable has no conceivable limit, but it increases by 'unbelievable' discoveries and designs.
Any *desire* must be imaginable, but I doubt if all possibilities are also imaginable.

The limit of the **possible** is not determined here by what is currently possible at the moment, but what can be ever possible technically and practically. That limit is not certain. For the time being, I accept the limitations that are generally accepted by science such as the impossibility of a perpetuum mobile.
You can, however, develop new possibilities that were previously unimaginable.
Our imagination expands in a learning process with conditions for new images.

Since science is a human design, it is itself limited by human imagination, language and underlying suppositions (conditions for imagination).
In order to gain some insight of these limitations, I have described in more detail some typical parts of the physical, biological and human sciences from my own limited knowledge (chapters 7 to 10).

The question remains whether these reconstructions ('science') of the actual (accesible by human action) reality also covers *all* technical possibilities.

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a A variant on Wittgenstein(1918)Tractatus logico-philosophicus(Berlin 1963)Edition Suhrkamp Vorwort

The instruments with which our exploratory capacity has been extended, are human designs themselves. Mathematics, mainly considered as untouchable, is such an instrument. It reduces differences and changes to equalities and repetitions (chapter 7 p123). It is a generalizing instrument. That is an important limitation.

I do not share the Platonic idea that ideas are a condition for material existence. Even mathematics as a world of ideas does not escape our physical conditions, however much it helps us to get to know them.

It makes the endless repetitions with which we are confronted manageable. Repetition of mathematical operations can lead to a variety that is reminiscent of biological forms, but they are limited to *exact* repetition (§ 28 from p150 onwards).

You always can imagine a lager **level of scale (*Fig. 7*** p24), but not always a smaller one (approaching zero).
So, a smaller level of scale should suppose a larger one (think of relativity p185).[a]

You may, however, understand the conditions of attraction and repulsion (p178) best reasoning from the smaller scale (electrons and protons) into the larger scale (electric devices). The same accounts for quantum physics (p189) and biotics (chapter 9 p214). So, I doubt if the levels of scale do have a conditionality.

The layers of **context** and **object** are each consecutive conditions for their imaginability (***Fig. 54*** and ***Fig. 55*** p120).
The **context layers** as represented in ***Fig. 7*** p24, however, raise the question whether governance, economy *and technique* are not *parts* of culture, a 'set of shared suppositions and material conditions'.

Some kinds of technique in the sense of 'skill'[b] are supposed in any local culture. These are actually not different from numerous *biotic* mechanisms. They exist globally, inescapable as practical conditions for every contemporary economy and culture, including general human skills (observing, moving, manipulating) by nature.

The *invention* and *knowledge* of techniques (*technology*), however, is culture.
A local culture, such as in Silicon Valley, could produce technological innovations, but after that, they started to live their own lives globally as a given context.
They have offered all local cultures new conditions to explore new possibilities.

Something similar applies to an economic competitive structure referring to a more general biological 'survival of the fittest' that you cannot evade.

The **object layers** in ***Fig. 7*** p24 are identifiable moments of attention and representation in each design process. They also each require a different imagination. Since an object can always be placed within a context, but not the other way around, the object layers should be part of each context layer, but *design* requires technique.

---

a The fourth dimension 'time' seems to indicate future ⇓ past, but than does not concern the time *scale*.
b The original Greek wordt technè (τέχνη) means art, fitness, skill.

SHIFTING DISTINCTIONS ENABLE DESIGN

The first condition for our imagination is discernment, the ability to distinguish objects in some state of dispersion (form).

For *design* that ability must be more flexible than for just *using its result*.
You should not only be able to recognize familiar objects that already have a name.
You must also be able to imagine objects with different contours (shifting borders).
The content even should not yet have a name.

For example, constellations of stars have got a name (eg Orion).
So, you can remember and recognize them easily.
The starry sky, however, has infinite possibilities to capture a collection of stars in a constellation. You can add or omit elements in your image.

If you add a third dimension to the image, then suddenly quite different groupings are possible. This earlier caused a Copernican revolution, changing the representation as a sky dome into the conception of an infinite universe.

Biotics include technique by shifting distinctions

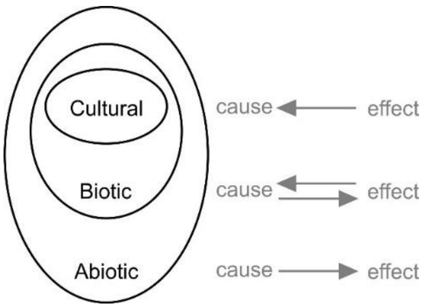

Fig. 8 ABC model

The context layers in ***Fig. 7*** p24 raised the question whether technology and economics should not be counted as 'culture'.

The summarizing ABC model of ***Fig. 8*** is a simplification that avoids this question without losing the main sequence of implication.

Moreover, it is a representation in which the order of cause and effect reverses.

The causal thinking, anchored in our language (subject-verb-direct object), loses its direction from cause into effect in biology (chicken or egg).
Consequences interact with the causes (reciprocity, adaptation through feed back).
That mechanism is followed in the technique ('cybernetics').

Imagination can reverse time.
You can first anticipate the consequences and then cause them to be so.

Van Leeuwen's re(gu)lation theory shifts borders

The ideas of the ecologist Van Leeuwen shift some crucial boundaries in conventional distinctions. My shortest summary of his ideas would be the following.

The only premise that has no longer any suppositions is the concept of 'difference'.
Every other concept supposes a difference with other concepts.
Everything differs. 'Equality' is only a special case of difference: an imaginary 'zero value', a limit that only can be approached.[a]

a You can already find this view at Cusanus(1440)De Docta Ignorantia II, 1 p92 and Leibniz (1663-1716) Kleine philosophische Schriften (Leipzig1879) Koschny p127 "... dass es niemals eine völlige Gleichheit geben wird." (Was zu einem meiner wichtigste Axiome gehört.) ". This is

010 R&T Variation.xar

Also 'change' supposes difference (with 'now') and stability, duration, is such an imaginary special case. Everything changes (panta rhei[a]), albeit to varying degrees.

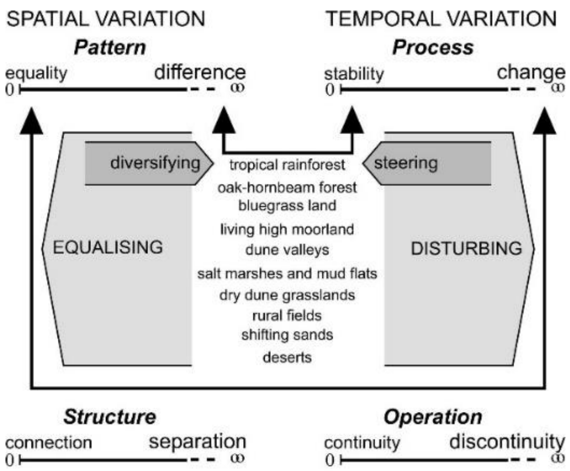

Fig. 9 Van Leeuwen's spatial and temporal variation

According to Van Leeuwen, between this 'spatial variation' and 'temporal variation' there is a predominantly negative (not causal) relationship (***Fig. 9***).[b]

Most likely is a relationship between decreasing difference and increasing change ('equalizing' and 'disturbing').

The *reverse* ('diversifying' and 'steering'), however, is itself a change.

So, *increasing* diversity and *decreasing* change, implicitly couteracts itself: it disturbs.

Making a difference then is more difficult than easily equalizing a difference.[c]
The concepts of 'difference' and 'change' are more fundamental than the abstractions 'space' and 'time', *derived* from observed differences and changes.

These abstractions are here sometimes used as adjectives ('spatial' and 'temporal'), but their use is meant only to distinguish the two 'variations'.
'Variation' can be interpreted as 'difference in difference' and the difference between the two variations as a third degree difference: 'difference in difference in difference'.

The assumed negative relationship between the two variations reminds of the second law of thermodynamics, the entropy law that states that any system develops into more disorder (a higher entropy or probability see § 34 p194).
Van Leeuwen, however, associates this disorder with more equality and change and the process towards more disorder with equalizing and disruption (***Fig. 9***).

This relation of pattern and process is repeated in *structures* and *operations*: connection makes discontinuity more likely than separation; separation gives a greater chance on continuity. Connecting and separating, however, are themselves operations that cause discontinuity. Separation is therefore more difficult than connecting.[d]

This appeals designers: draw the walls first, and then the gaps.
For them, 'structure' is usefully defined as a 'set of separations and connections'.

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remarkable for a great mathematician. With regard to change, he also states on p221: "Streng genommen ist es richtig, dass kein Körper vollkommen und gänzlich in Ruhe ist, aber man sieht bei einer mathematischen Betrachtung der Sache davon ab.". In this way he puts the reality content of mathematics into perspective: nothing is really the same or the remaining equal, everything differs and changes. With him, just as with Van Leeuwen, time is no more than an "order of change" (p111): "…der Zeit, welche dem Geiste nur eine Ordnung in den Veränderungen darstellt, …".

a Attributed to Heraclites, among others by Plato.

b Change is a form of difference in the fourth dimension. There is therefore some reason to propose the time dimension as perpendicular to space. In this case, between spatial and temporal variation, according to Van Leeuwen, a perpendicular paradox applies as a special case of the spatial paradox that equality appears perpendicular to difference. Thus, technical possibilities such as the selectors of ***Fig. 10*** appear.

c Every child knows that if once it has built a sand castle on the sea front. That is always leveled by indifferent vandals or the sea.

d Jong(2007)Connecting is easy, separating is difficult In: Jong; Dekker; Posthoorn eds. Landscape ecology in the Dutch Context (Zeist) KNNV-uitgeverij p208. http://www.taekemdejong.nl/Publications/2006/Landschapsecologie/Onderdelen2/Connecting is easy.doc

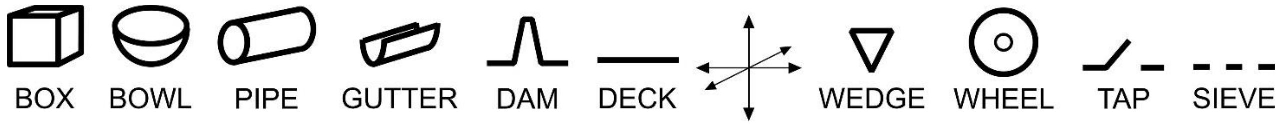

Fig. 10 Selectors, the elements of structure

You can imagine separation in 6 directions (6 'degrees of freedom' for movement, two opposite per dimension): in 6 directions as a box or cell from which you cannot escape, in 5 as a bowl, in 4 as a pipe, a tube (or an armchair), in 3 as a gutter or slide, in 2 as a wall, in 1 as a deck (***Fig. 10***), and in no direction as a void.

Van Leeuwen called these elementary structure components 'selectors'.[a]
If you involve the temporal variation (*alternating* separation and connection) then a wedge (to *make* a separation), a wheel (rotation about one direction), or valve (door, tap, switch, transistor) are also selectors. If a separation is selective with respect to size or other qualities, then you have a sieve (filter, membrane).

The membrane is a foundation of living organisms.
A cell is a selectively enclosing membrane (box) that sifts input and output.
This enables an internal arrangement, which can hold up against the ubiquitous, ever increasing external disorder ('entropy').

Tubes in an organism nourish its cells with low entropy, and they drain the superfluous substances with a higher entropy outwards.

This concept of structure is also crucial in technology. Each device is a set of selectors that work together connecting or separating elements from each other.[b]
The terms 'organ', 'organism' and 'organization' already suggest that structures at different levels of scale (bounded by frame and grain) deserve their own approach.

Vague boundaries extend differences

A vague boundary ('gradient', ***Fig. 5*** p17) is a sequence of consecutive differences that take up space, offering different possibilities for survival. Fluctuations do so in time.

Van Leeuwen found more different and rare plant species in gradients than elsewhere.[c]
After all, on a broad gradient, for example from high to low, more different species with different moisture requirements can find their own optimum (the more generally accepted concept of 'ecological tolerance' ***Fig. 11***).

A sharp boundary has fewer differences and less species in its environment, but as a front line also more competition and dynamics. Van Leeuwen therefore proposed to concentrate our nature policy on sustainable vague boundaries (gradients) and not on the categorization of ecosystems with 'target species' on both sides.[d]

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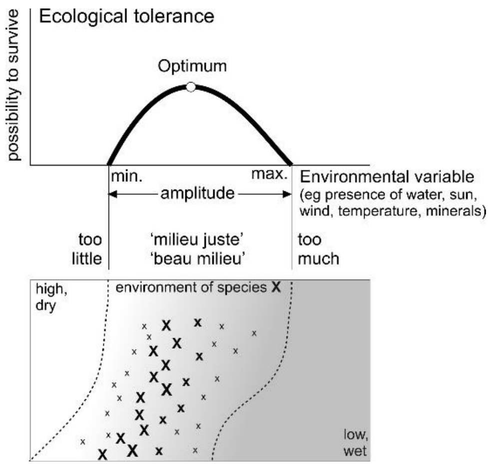
a Leeuwen(1973)Ekologie(Delft)TUD Sektie Landschap p35
b See Rodenacker(1976)Methodisches Konstruieren(Berlin)Springer.
c Leeuwen(1965)Over Grenzen en Grensmilieus(Amsterdam)Jaarboek 1964 van de Koninklijke Nederlandse Botanische Vereniging
d This view was taken over in VROM (1966) Second Policy Document on Spatial Planning (The Hague) State publisher p109 and resulted in a 'gradient map'. For a short time this was the norm for nature policy in The Netherlands.



The species X flourishes at its optimal height, but it is surrounded by languishing specimens x at slightly too dry or too wet locations.
If it stays dry or wet for a long time, these marginal specimens will flourish instead.[a]

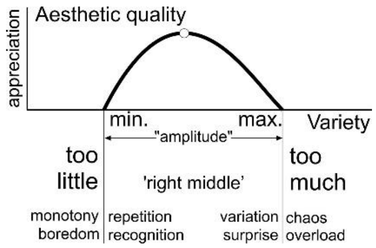


Fig. 11 Ecological tolerance

Fig. 12 Aesthetic quality(variety)[b]

That *categorization*, however, yet became the basis of Dutch nature policy. Ecological categorization is probably the most laborious and questionable form of scientific categorization[c]. It became outdated by climate change and other accidental succession of environmental influences. The characteristic species composition must always be adjusted or further divided, but the landscape *gradients* still exist.

Van Leeuwen's view has far-reaching consequences for the design of science and for design itself.[d] Categories (sets) are primarily determined by external *differences* and boundaries, and not by internal generalization of supposed *equality*.
That makes many usual categorisations and generalizations questionable.

Diversity compensates change and the reverse

Van Leeuwen assumed a compensatory relationship between spatial and temporal variation in the landscape (***Fig. 9*** p27).[e] He left the causality direction in the middle.

'*Change equalizes ('pioneer vegetation'), rest diversifies ('climax vegetation')*' is commonly accepted in ecology, but the impact of '*Equality causes change and diversity causes stability*' is less understood. It becomes important if you take into account *abiotic* diversity and the diversifying effect of *selectors* in the landscape.

This 'relation theory' (or perhaps better 'regulation theory') is criticized with methodological assumptions hitting many accepted scientific theories as well[f].

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a In that sense, gradients and fluctuations are risk coverages for survival of species.
b On page 32 I will use ecological tolerance as an analogue for aesthetic quality.
c This 'plant sociology' distinguishes vegetation in areas where the same composition of species is often found as 'societies' and gives it a Latin name. The distinction between very heterogeneous collections that have something in common yields complex methodological problems, see Schaminée (1996) The vegetation of the Netherlands (Leiden) Opuluspress. The plant-sociological vegetation categorization and mapping for the Netherlands, under the direction of Westhoff from 1942 with an admirable perseverance was established. A true monk's work. At least ten bulky folios filled with tables with field recordings saw the light. The system, generally known and accepted as the 'Westhoff-Den Held' system, was later regarded as unsustainable by Den Held in inventories in South Holland.
d Jong(2003)Het belang van ecologie voor bouwkundig ontwerpen en omgekeerd (Zoetermeer) MESO http://www.taekemdejong.nl/Publications/2003/Het belang van de ecologie.htm
e Leeuwen(1970)Raumzeitliche Beziehungen in der Vegetation in: R. Tüxen Gesellschaftsmorphologie Strukturforschung(Den Haag)Junk 63-68 en Leeuwen(1971)Ekologie(Delft)THD 3404
f Sloep (1983) Patronen in het denken over vegetaties: Een kritische beschouwing over de relatietheorie (Groningen) RUG. This dissertation appeared at the same university (Groningen) where Van Leeuwen had received an honorary doctorate for his relation theory a few years earlier.

This criticism may be largely overcome by recognizing the paradoxes of scale (***Fig. 6*** p18) and perpendicularity (***Fig. 5*** p17). Van Leeuwen could be right on some levels of scale, but (without contradiction) not on other levels. This invites additional research to determine the levels of scale where a change of paradigms may take place.

Here is especially important, that the abstract concepts of space and time cannot be imagined without directly perceptible differences and changes. Vice versa they can. The intellectual constructions 'space and time' *suppose* 'difference' and 'change'.

EQUALITY SUPPOSES DIFFERENCE

In this study I accept Van Leeuwen's underlying insight of equality as a special case ('zero value' or limit) of difference, and stability as a special case of change. Differences can always be thought of more different, but not always less different. Less than the smallest observable or imaginable difference is *called* 'equality'.

With a microscope or telescope you can always see more differences (even if it is only a difference of place, form). The result is, that 'equality' does not have to be in logical contradiction with 'difference', and 'stability' not with 'change'. There is only a *degree* of difference and change. That degree, however, may differ per level of scale.

In physics and chemistry, 'equilibrium' is primarily associated by equality, stability and high probability (entropy) on two levels of scale: few particles (mechanics) and many particles (thermodynamics) with a high probability of dispersion in space (as long as attractive forces are smaller then the repulsive ones).

Biologists, however, associate 'order' and 'equilibrium' primarily by high degrees of *difference* and *change* of cells, organs, organisms and organizations in between these two levels of scale in physics. Life *concentrates* some particles, leaving others to entropic *dispersion* (differently at many different levels of scale).

'Chaos' may be a popular name for the *diversity* of quantities, often caused by *equal* operations (changes) repeatedly feeded back by their own result (iteration, § 28 p150). That is not surprising if you take equality and stability as special cases of difference ⊥ change (such as equal operations). Pependicularity solves verbal contradictions.

The term 'far from equilibrium', then means 'less entropy', ('more order').
The term 'close to chaos', translated as 'close to diversity' is confusing, if there is only a *degree* of diversity with an infinite maximum.

§ 5 DIFFERENCE APPEARS IN THE SENSES, EQUALITY IN THE MIND

YOU CANNOT PERCEIVE, CHOOSE OR THINK WITHOUT A DIFFERENCE.
Difference is supposed in any modality of ***Fig. 3***, p15, in our senses *and* in our minds. It is the single and only required 'a priori' category for both.
Everything differs, but sometimes we *conclude* equality.

Every object we give our attention must first be chosen and separated from a formless multiplicity, before it can be thought of as a manageable unity.
Our language, our limited imagination and memory force us to select with sharp boundaries[a] and to further reduction and generalization of data within it.
Design, however, begins with an empty and vaguely bounded object.

Our minds, our language and science reduce every unmanageable multitude in sets with a label, a word. Words generalize similarities in concepts, types, classes, categories. They reduce the variety of passing images to imaginary equalities, to find rules that can make our own actions (including thinking) effective.

If everything is made equal, and suitable for repetitive operations, however, then your attention weakens, you get 'bored', and you need to be surprised by new impressions. You move between monotony and chaos, boredom and surprise (***Fig. 12*** p29 and 272). These limits and the optimum between them (aesthetic quality) differ per person.

Alexander[b], however, claims 90% equality in aesthetic appreciation of humans.
For him, it is a trustable human intuition, recognizing the right balance between order and chaos for self-organizing systems.

A THIRD OBJECT IN THE IMAGE MAKES THINKING IN SETS POSSIBLE
According to some biologists[c], humans distinguish themselves from animals by the ability to oversee a series of actions of which only the first is directly executable.
I would add ', and of which only the last has an outward function'.
I call the intermediate actions with a function only within that series 'interfunctional'.

Making tools, following a course, using language to coordinate actions are all 'interfunctional actions' with a more distant purpose.

Inter-functional actions can also be found in animals (nest construction, partner search, hatching care) and even in biochemical processes (chemical pathways), but the criterion of Harrison et al. differs in the word 'oversight', the con-cept[d], the co-action (see note p18) that accompanies or even precedes the successive actions.

You do not have to assume that birds building a nest oversee their reproduction cycle. Such a genetic program component is executed more directly by animals than by

a Dick Bruna has helped millions of children in different cultures to recognize concepts by sharp boundaries. Linders(2006)Dick Bruna(Zwolle)Waanders.
b Alexander(2002)The Nature of Order Book 1,2,3,4(Berkeley)The Center of Environmental structure, summarized in Alexander(2003)New Concepts in Complexity Theory.
c A demarcation criterion between humans and animals in Harrison;Weiner;Tanner;Barnicot(1964)Human biology(Oxford)The Clarendon Press
d latin for 'taken together'

people, *planning* intermediary actions. The input of animals is only a variation triggering subroutines of the compulsory program (twig search, plaiting, twig search, plaiting). These are carried out differently depending on actual circumstances.[a]

The 'overseeing' of actions in animals is probably no more than two actions that can be considered (flee or fight, chasing away or luring, nesting or eating) or alternated (hunting-eating).

The urgency is determined by the physical state in which they find themselves.
An 'unblocking stimulus'[b] from the environment triggers subroutines (the appearance of a prey or predator, the temperature of the approaching spring, the concentration of chemical attractants).

People have a greater variation in their activities than repetitive processes or routines. Humans may oversee more actions than animals, and three of them (see p60: 'Three' is an innate limit[c]) already can explain their variation of activities.

If the overview (con-cept, a co-action, see note p18) is a part of three actions imagined at the same time, then there is an interfunctional action in the representation available between the first and the last action.

An action itself can be included as an object in the representation between two objects such as a start and an end stage, specifying an 'activity'.

A verb (an operator between two variables), surrounded by two nouns: an active subject and a direct object (or result), already enables a language of full sentences.
Speaking itself is a 'series of actions of which only the first is directly executable'.

If the sequence is often performed, an older neural system takes over the 'routine'.
The series, however, may be interrupted by an incident in the environment.
This can come from outside, and eventually be a side effect of your own action.

These are often creative moments that distract and open a new route.
Their 'third object' gives people more space than animals to follow a different series of actions. The 'third object' in the image is evolutionarily a minor neural mutation with major consequences.

A memory cannot only be seen as educational experience from the past in addition to the sensory topicality, but in the same image there is also room for a future.
This third object thus makes conscious 'wanting' possible. A third object can contain the sequence between two stages and develop to the abstraction of 'time'.

a Hall;Meddle;Healy(2015)From neurons to nests, nest-building behaviour as a model in behavioural and comparative neuroscience(J Ornithol)156Suppl1p133–143

b Tinbergen(1965)Social Behaviour In Animals(London)Methuen, discusses numerous examples of unblocking incentives. He argues that there is no way in which anticipated effects of behavior can play the role of the causes of behavior, as is the case in humans.

c Feigenson;Carey(2005)On the limits of infants' quantification of small object arrays(Cognition)97 295–313

From two different objects one similar characteristic can be detached and presented as an adjective 'third object' (apple, egg, *round*): a first form of 'analysis' (separating a property), 'abstraction' (conceptualization of roundness) and categorization.

Two similar objects can be summarized in a third object: their 'set' (round objects). Two sets of actions (now two objects) then can be coordinated into 'cooperation'

'SET' SUPPOSES A BOUNDARY

Each concept, word or category refers to a set of objects (extension) that resemble each other ('equal'), in pairs. They are then summarized in one third object (the 'set'). Concepts are usually defined with equal 'properties'.
That supposes, however, at first difference with the rest, or more precise: more different with the rest than with the other objects in the set ('elements').

So, sets can be better defined with that difference at their boundary.
You also draw them that way in Venn diagrams, although you *describe* them with common characteristics ('properties'). This solves Russell's paradox that a set cannot contain itself as an element.[a] The borders coincide, so that it contains itself on the outside, but not on the inside: a matter of view direction or definition.

After the similarities, you may discover differences within the set (for example isotopes of the same element, subspecies of what was first known as one species): subsets. With the 'years of discernment' the awareness of differences within a set grows. You learn to make a difference in which was first considered as equal.

Science generalizes by nature. It cannot easily deal with increasing diversity. Biology is the most used to it. About one and a half million species are known, but new species are still being discovered and subspecies are distinguished.
Moreover, to our scientific annoyance we must then admit that every individual differs *within* each species (an insight that physicians only reluctantly accept[b]).

Further classification leads to ever smaller subsets.
Statistics will get less and less grip on these subsets in the face of an increasing lack of sufficient cases. To make it completely unmanageable, it turns out that every individual ends up in a different environment, and behaves differently in that context. What then remains of definitions, if you only have generalizing words available?

DEFINING SUPPOSES CONSTITUTING, NOT THE REVERSE (CARNAP'S FAILURE)

A definition (finis is latin for 'boundary') requires that the terms with which the definition is defined ('definientia') are not already included in the description or image of what has to be defined ('definiendum').
That would result in a circular definition floating in the air.

a Russell(1903)The Principles of Mathematics(Cambridge)University Press p101 WWW2016 http://fair-use.org/bertrand-russell/the-principles-of-mathematics/index

b A drug or therapy would then have to be tested per individual before it was prescribed, because the average effect for a group neglects many rare, but potentially dangerous, individual effects.

If you then want to define the definitive concepts in their turn, then there are fewer and fewer concepts that you can use in those definitions. Where does that start?
Carnap (1928)[a] has worked out rules for a definition tree with which our personal ('eigenpsychische') experiences can be translated into symbolic logic ('Konstitution'[b]).

His Konstitution distinguishes our experiences in numerous terms with German names that you have to remember in order to understand the following paragraphs.
Then they have to be assembled into logical symbols to form a long, branched staircase with *definition* steps.[c]

Later, in the foreword to a second edition in 1961, Carnap admitted "daß die Zurückführung höherer Begriffe auf niedere nicht immer in der Form von expliziten Definitionen möglich ist": you cannot build a constitution with explicit definitions.

Constituting is something different from defining
You do not have to formulate any *necessary* conditions for a subsequent concept, but conditions of *possibility*. Otherwise you would never be able to make *new* representations.[d] Such a backward constitution is unusable for designers.

Carnap leans heavily on Russell (1902), the forerunner of logical positivism.
That implies that the foundation of our thinking consists of propositions, classes and relationships. Russell (1902) claims in §26 p23: "Diversity is defined as the negation of identity[e].", and in §55 p50: "... difference becomes a class concept of which there are many instances as there are pairs of different terms; ... ".
Then 'equality' is also a class, or should I just deny it via that 'negation'?

Carnap (1928 §75 p105) concludes that a constitution theory should not start with a class but with a relationship: "Relationen als erster Setzungen, da zwar von Relationen leicht zu Klassen übergegangen werden kann, das Umgekehrte jedoch nur in sehr beschränktem Maße möglich ist."

The distinction between relation and class is circular
There is something in it[f], but in §108 p150 he chooses 'Ähnlichkeitserinnerung' as the lowest step of his staircase. Is 'Ähnlichkeitserinnerung' a relationship if difference (according to Russell) is a class? Perhaps that 'Erinnerung' is the relation and 'Ähnlichkeit' is the class you are remembered about.

He calls 'Ähnichkeit' a relationship between objects, and then put them in a class. Classes then have an internal 'equality', but they must differ externally, otherwise you do not know which class of 'Ähnlichkeiten' you have to remember.

a Carnap(1928)Der logische Aufbau der Welt(Hamburg 1961)Felix Meiner.
b I will use this term in somewhat modified sense as a 'constitution' and reserve the spelling 'Konstitution' for what Carnap means by it.
c This shows that you first have to make distinctions (differences) before you can put them back in generalizations (equalities).
d Carnap(1928) only assembles the existing. He states explicitly in §144 p193: "… auf keiner Stufe des Konstitutionssystems, also auch nicht durch die Verwertung der Angaben der anderen Menschen, etwas elementar Neues in das System hineinkommt, …"
e meant as mutual equality
f Carnap(1928)151 p202 " Ein solches Gebilde (z. B. ein Stamm, eine Familie, ein Verein, ein Staat usw.) muß als Relation konstituiert werden, nicht als Klasse, weil die Ordnung der Glieder innerhalb einer soziologischen Gruppe zum Charakter der Gruppe gehört. Die Unzulässigkeit der Konstitution als Klasse folgt schon aus der Möglichkeit des Zusammenfallens der Personenbestände zweier verschiedener Gruppen."

The distinction between 'relation' and 'class' then supposes 'relationship' itself and there are 'classes of relationships'. Relationships then are also objects and their set is again a class. That whole distinction between relationships and classes is circular.

You just have to consider the scale paradox on two sides.
If there are objects between which you find similarity, you give their set a name that distinguishes it from other sets. The comparison of objects supposes that these are mutually different objects, otherwise you could point out the same object ten times and find that they are 'equal' (or even worse: that there are ten objects).

An object must occupy a place or time that is not occupied by the other object, in order to compare them. That primary *difference* of place or time applies to objects that we have in mind as well as those that take place outside of us, so that we can 'place' and distinguish them by senses *and* in thought.

That is, by the way, a nice starting point to avoid metaphysical discussions about the duality between body and mind.

Constitution goes beyond truth
If you reserve the term 'constitution' for the suppositions that make a next representation *possible* a instead of *true* or *probable* ('definition'), then that replaces Carnaps 'definitions'. It immediately prevents the suggestion that a next step with definitions only yields the same with other words.[a]
It can open step by step new possibilities, building on the once existing.

For such a constitution also applies, as in the case of definitions, that the constituents ('constituents') may not occur in the description or image of what is to be constituted ('constituendum').

By 'concepts' I do not only mean words, but especially images. In constituing, the images by which you imagine something precede the words you make up for them.

Therefore, just as much as with definitions, fewer and fewer words or images remain, with which you can constitute something, if you want to constitute the constituent concepts in their turn.

The question then is, where that ends, or in other words: where starts our imagination? I want to answer that question here. Carnap thought it started with "memory of parable". I choose 'difference' of which equality is only the limit.

You cannot derive anything new from equal equalities[b], from different differences you can, even a concept of 'equality'. A number is also a difference: the difference from a object '1' repeated in two directions: one counts into zero, another into two.

a A suggestion against which Carnap (1928) §151 p203 still has to defend itself with art and flying work: " … daß die Konstitution eines Gegenstandes auf Grund bestimmter anderer Gegenstände ... nicht besagt, daß der Gegenstand mit den anderen gleichartig sei, sondern im Gegenteil: wenn die Konstitution … zur Bildung neuer logischer Stufen fuhrt, so gehören die konstituierten Gegenstände einer anderen Seinsart, … ". Then he has to explain what 'Seinsart' is. I think you're working on it for a while.

b Carnap(1928)§110 p151 believes that to solve introducing 'Teilähnlichkeit' for a next step after the first 'Ähnlichkeitserinnerung'.
That subdivision of equality supposes secretly 'difference' in the total 'Ähnlichkeit'.

In physics it is a difference from a physical unit, for example the meter that is kept in Paris, or a difference with the swing time of a 1 meter sling on earth according to Huygens (approximately one second).

§ 6 A STUDY OF PRACTICAL CONDITIONS REQUIRES DESIGN

STARTING POINT, PROBLEM, PURPOSE AND HYPOTHESIS ARE DESIGNS

By the previous sections I hope to provide sufficient insight into my **starting points**. The first principle is the assumption that every representation is built on suppositions (conditions for imagination). These are based on a long series of deeper, often tacit, preconditions that have been learned one by one in a conditional order.

The **problem** is: some suppositions are necessary, but others may block imagination. The question is, however, which tacit assumptions are strictly necessary for design (finding possibilities) and which are not, or even counterproductive.
That is difficult to determine.

The suppositions that suppose each other have a sequence.
To build a house you should no start with the roof, but with the foundation.
The aim of this study is not to cover all usual constructions.
The **aim** is to broaden our practical imagination by removing useless blockades.

This should, however, not lead to unreal fantasies, but to improbable *and* realizable *possibilities*. You should construct a minimal set of suppositions which must pass in every real design process. My **hypothesis** of that minimum is a field of 15 'picket posts' in the ABC sequence from ***Fig. 8*** on p26 with which my previous attempt[a] ended (read ⥣ as 'is supposed by' or 'enables imagining'):

Abiotic	:	difference	⥣	change	⥣	coherence	⥣	selection	⥣	combination	⥣
Biotic	:	metabolism	⥣	regulation	⥣	organization	⥣	specialization	⥣	reproduction	⥣
Cultural	:	information	⥣	security	⥣	affection	⥣	identity	⥣	influence	

Fig. 13 A hypothetical constitution of the imaginable

So, Abiotic suppositions enable Biotic ones, Biotic suppositions Cultural ones. **Difference** can be added everywhere. So, **change** ⥥ (supposes) difference in difference; coherence ⥥ difference in change; selection ⥥ difference in coherence; combination ⥥ difference in selection.

The arrangement of this table shows also a special vertical relation:
metabolism ⥥ difference in combination; **regulation** ⥥ change in metabolism;
organization ⥥ coherence in regulation; **specialization** ⥥ selection in organization;
reproduction ⥥ combination in specialization;
information ⥥ metabolism of reproduction; **security** ⥥ regulated information;
affection ⥥ organized security; **identity** ⥥ specific affection;
influence ⥥ reproduced identity.

The conditionals ⥣ and ⥥ are transitive, so you may conclude: difference ⥣ influence. The conditionals of ***Fig. 7*** p24 then also could be inserted somewhere in ***Fig. 13***.

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a Jong(1992)Kleine methodologie voor ontwerpend onderzoek(Meppel)Boom p41, repeated here with some changes.

So: **governance** ⇓ influence; **culture** ⇓ identity; **economy** ⇓ security; **technique** ⇓ reproduction; **biotics** ⇓ reproduction; **abiotics** ⇓ combination. ***Technique*** then may be subdivided in **intention** ⇓ **function** ⇓ **structure** ⇓ **form** ⇓ **content**.

Fig. 13 is not the only possible constitution. The words also do not fully cover the image I had in mind, but they are the best covering ones I could find.
The **method** is simple: check if you cannot imagine B without A, then A is supposed in B.[a] If you can, then A is superfluous and potentially blocking your imagination.

The challenge is, however, to choose and distinguish the relevant A's and B's in words. Which suppositions should you to check on their sequence?
Which supposition is the first, whereupon you can build *any* imagination?
That supposition would be the only one not having any supposition itself.

You need a first supposition and an image of the rest, a hypothesis.
That is on itself a design. You may prefer another design. Please, *make* it.

My hypothesis is ***Fig. 13*** on p37, beginning with Van Leeuwen's 'difference' (p30) as the first supposition. It includes 'equality' as its limit value. 'Equal equalities' do not produce something new. 'Different differences' do, but it confronts us with a paradox. There is 'more' and 'less' difference, there is difference in change, and so on.

Anything differs. So, different differences suppose *categories* of difference, such as a quantity of difference (more or less), difference in change, direction (eg dimensions x,y,z,t), in content, form, structure, function or intention etc. of any *object*.
The paradox is, that *categories* of 'different differences' suppose internal *equality*.

Van Leeuwen solves this paradox by concerning equality as the least imaginable difference. That *implies* the possibility of 'more' or 'less' difference within this concept of difference itself. You may take 'difference' primarily as difference in space, but the intention of designers is also, to make a difference in time: *change*, the second supposition in ***Fig. 13*** on p37.

I want to test its potential for imagination. Does it unlock the usual scientific vocabulary without blocking the possible worlds of design? This list is predominantly linear, but roots, branches and crossings are not excluded: an object can require more suppositions at the same time; the staircase can be split in several directions.

It could have been a task of philosophy to clarify or (re)construct such structures, but that task has been lying too long since in Carnap(1928) the classic logic failed.
Philosophy gets stuck in the mode of truth and desirability (ethics), it lacks the mode of possibility, design. It still consists mainly of its history. Even philosophers with assumptions being long overtaken by science are still ruminated.
There is, however, an extensive field of more urgent philosophical research outside.

a In this text, however, it depends, on *my* imagination.

The physical (Abiotic, Biotic) and whether or not shared Cultural or Conceptual possibilities (ABC in ***Fig. 8*** on p26), are our conditions for survival.
To the best of my knowledge, I will describe some examples of scientifically often tested suppositions in chapters 6 to 10 as brief and understandable as possible in an ABC sequence. You can check for each component whether the above series suffices.

This should clarify the boundary where empirical science stops and design begins.
A more difficult task, then, is to delete assumptions that are not strictly necessary for a feasible design, or even block the view on what is possible.
I am not able to finish that work by checking every word in our vocabulary.

KNOWLEDGE SUPPOSES INDIVIDUAL CONCEPTUAL CONDITIONS

If you want to know the order of Abiotic, Biotic and Cultural conditions for our imagination in detail, you will encounter a familiar circular argument.
Such conditions are already supposed in the 'knowledge' of conditions themselves.
Some concepts therefore must precede the ABC of ***Fig. 8*** on p26.

Knowing ABC is then ... cABC .... That first c of individual understanding is a condition for the second C ('the *commonly shared* suppositions').
In order to distinguish them, I call this first c 'conceptual conditions' and the second commonly shared conditions for imagination, 'Cultural conditions'.

In each of us, these conceptual conditions have been developed step by step from birth to ever more learned assumptions: ... $_{cABC}ABC$… .
The circular reasoning then is an empirical cycle. If I first make a presentation of the child psychological development that every adult must have experienced, then you can judge from your own experience whether that representation is plausible.

If you agree, then a reasonable kind of objectivity is created as a basis for next steps. Carnap (1928) called this foundation 'eigenpsychisch' and took that as the basis for his 'Konstitutionstheorie'.

In chapter 8 p 177, I will start with A as if it were physical facts that exist outside of our consciousness, regardless of how or by whom they are described.

We get images of it from everyone's long series of 'eigenpsychische Elementar-erlebnisse', but that is flawed. It is not 'a priori logical', but conditionally reconstructable. Those pieces have to be rearranged and, as a jigsaw puzzle, produce a contiguous representation in more directions.

Our 'knowledge' of the outside world develops in parallel (co-agitating, see note p18) as a reconstruction or simulation of what we have observed.
We assume that this knowledge enables us to survive in that outside world.

The possibility or *ability* to know, however, supposes a preliminary development of imagination. This development can be reconstructed from individual child's play and from general cultural history.

2 THIS STUDY REDUCES BLOCKING SUPPOSITIONS

Cultural history begins in prehistory with preserved objects, without verbal remains.[a] The verbal language is a revolutionary invention, a tool that can partially express our supposed 'knowledge' in a linear, action-oriented, generalizing form, captured written.

Within this development 'logic' is created as correction of a limited number of connections (conjunctions) in our language (logos), but not in the world outside.

Logic is not innate 'a priori', but an invented language tool for manipulating sets.
The same applies to mathematics: a logically correct language enabling to handle more equalities and repetitions than with which our thinking faculty is equipped.

IMAGINATION BEGINS WITH CHILD'S PLAY

That I must start with some primitive conceptual conditions, before I systematically reconstruct the suppositions of our imagination in ABC order, has another reason.

The child psychological development can itself be presented as a conditional series of suppositions that consecutively build on each other.
With this, chapter 3 p48 offers a pre-exercise for the systematic constitution.

The reasoning of chapter 3 is roughly as follows:

You cannot imagine:

an object without different directions;
a sequence without different objects (and directions);
a size without different sequences (, objects and directions);
a distance without different sizes (sequences, objects and directions);
a place without different distances (, sizes, sequences, objects and directions);
a quality ('attribute') without different objects in different places (,distance, ...);
a quantity of some quality (a variable).

These primitive layers of growing imagination are not congenital 'a priori' categories. In the long-term practice of the child's play, they have been demonstrably taught as conceptual conditions for adult life.

They each in turn require increasing *abstraction*: detaching an object in all directions form a context, loosening the *sequence* from a *set* of different objects, disconnecting the *size* from different *sequences*, and so on.
You could call this 'discernment' with a limit ('zero point') of 'indifference'.

Once you reached the 'years of discernment' (not only in ethics), you can imagine differences of quality and quantity. This is a condition to survive in different physical, technical, economic, cultural and administrative contexts (external conditions).

For that ability, *reading* and *writing* is strictly not even necessary.
There are illiterates who have brought it far. In order to be able to coordinate actions, social life does require a *language* in which differences of quality can be put into words (actions as verbs, other objects as nouns and all kinds of additions).

a Diamond(1997)Guns, Germs and Steel(New York)Norton gives a nice overview of her physically determined evolution.

Written language then dramatically expands the number of actions that can be summarized, memorized and exchanged in one image.

The mathematical language in particular makes long repetitions manageable with variables and operators. This in turn demands a precision of the everyday language in which logic (chapter 6 from p103) provides. In chapter 4, I come back on the meaning of the language itself and its practical limitations for imagination.

These are minimum conditions to make further abstractions and to get to know their further developed, more or less generally accepted assumptions. I will pass some of this from chapter 7 (p123) to the extent that I have understood them myself.
These are examples in which science has replaced old 'incorrect' assumptions in an empirical cycle with design moments (hypotheses, instruments).

After I have finalized very roughly some cultural conditions in chapter 10 p263, I can put them in the perspective of subjective conceptual conditions and culture itself.

That is just a sketch design, an illustration of the method. It should shed some light on generally accepted assumptions that are not strictly required to make new representations. A designer then can free her- or himself from unnecessary ballast.

SUPPOSITIONS SUPPOSE A CULTURAL EVOLUTION

Child psychology has leads for a systematic sequence of primitive suppositions. Everyone has personally experienced that sequence.

The historical sequence in which a culture (science in particular) replaced old assumptions with new ones[a], has some parallels with it.
Yet the cultural-historical evolution gives a less clear picture of successive conditions and suppositions.

How difficult it is, to abandon socially shared assumptions is evident from the old assumption that the earth is flat, or the center, around which stars spin and planets wander. This was refuted by Pythagoras, Plato, Aristotle, Eratosthenes, Copernicus, Kepler and Galileï.

The parallel with child psychology is the difficulty, to accept that not everything revolves around you, a crisis that every child experiences.
Piaget called that 'decentralization' (p56). There are events that escape your will.

There are still cultures and religions that attribute everything a 'will'.
In principle children also do this: a ball 'wants' to fall.

It takes years to get out of the modality of the desirable and to make way for the modality of an intersubjective or even objective truth and probability.
Even then you can still attribute to everything a 'divine will'.

a Dijksterhuis(1950)The Mechanization of the World Picture: Pythagoras to Newton(Princeton)University Press, gives a nice overview. All sorts of incorrect suppositions have held up the progress of science for a long time, but they have also been cleared by that same science.

To be able to place that modality within a much more comprehensive modality of the possible, apparently also takes much effort.
After Leibniz' 'possible worlds' it took centuries before the truth logic was expanded with necessity and possibility-operators ('modal logic'). Modal logic, however, still defined the potential as a truth-based statement: 'not necessarily untrue' (p113).

The *practical* possibilities with which a child without language starts experimenting from the outset, testifies to a more comprehensive modality of the possible.

Stevin preceded Galileï
A nice example of incorrect assumptions that lasted for a long time is the illusion that a heavy bullet falls faster than a light bullet (proportional to its weight) as assumed since Aristotle. It took almost two thousand years before Giambattista Benedetti[a] finally decided in 1553 that a bullet would not fall slower if you split it in two.

Stevin proved that in 1586 also experimentally, when he dropped two bullets, one ten times as heavy as the other, from the leaning tower in Delft.[b] They were heard on the floor at the same time. He could neglect the difference in resistance through the air at that distance. In any case, the 10x heavier ball was not 10 times as fast.

Galileo Galileï, professor in Pisa a few years later (from 1589 to 1592) did similar experiments, probably also from the leaning tower on the spot, but the heavy bullet always appeared to catch up the light one.[c]
This was no impediment for historians of science worldwide to attribute Stevin's successful test and his conclusion to Galileo's failure.

a Benedetti(1553)Resolutio omnium Euclidis problematum(Venice)
b https://adcs.home.xs4all.nl/stevin/weegconst.html Stevin(1586)De Beghinselen der weeghconst(Leyden)Plantijn. The test is described in the 'Anhang' thereof (p66): "Laet nemen (soo den hoochgheleerden H. Ian Cornets de Groot vlietichste ondersoucker der Naturens verborghentheden, ende ick ghedaen hebben) twee loyen clooten d'een thienmael grooter en swaerder als d'ander, die laet t'samen vallen van 30 voeten hooch, op een bart oft yet daer sy merckelick gheluyt tegen gheuen, ende sal blijcken, dat de lichste gheen thienmael langher op wech en blijft dan de swaerste, maer datse t'samen so ghelijck opt bart vallen, dat haer beyde gheluyden een selue clop schijnt te wesen. S'ghelijcx beuint hem daetlick oock also, met twee euegroote lichamen in thienvoudighe reden der swaerheyt, daerom Aristoteles voornomde eueredenheyt is onrecht."
c Galileï took notes of it, known as Galileï(1592)De Motu Antiquiora, but he did not publish them. (See http://echo.mpiwg-berlin.mpg.de/ECHOdocuView?url=/mpiwg/online/permanent/archimedes/galil_demot_094_en_2000). In it he refutes Aristotle on numerous points with calculations and thought experiments, among other things on the speed of fall. But he is confused by the outcome of his own fall tests. On p84 he writes (translated):"Yet experience shows the contrary: for it is true that wood at the beginning of its motion is carried more speedily than lead; but a little later the motion of lead is so accelerated that it leaves the wood behind, and, if they are released from a high tower, the lead gets ahead of it by a large distance: and I have often put this to the test." This doubt adorns him.
The manuscript is only published after his death in 1687, because the inquisition made it dangerous for the author and Galileï was apparently not satisfied with that manuscript. The only place where you could publish that kind of heretical ideas at that time was Holland. Stevin could publish in Leiden safely, all the more because he did so in the Dutch language that was unreadable for the inquisition. Galileï eventually did so during his life: Galileï(1638)Discorsi e Dimostrazioni Matematiche Intorno a Due Nuove Scienze(Leida)Elzevir, but for safety's sake in the form of a dialogue, so that the heretical ideas seemed to come from a different mouth. In that, the fall tests are also discussed.Van Helden(1995)On motion(WWW)http://galileo.rice.edu/sci/theories/on_motion.html gives an explanation for Galileï's failed drop tests, but I do not like it. In my opinion, a wooden ball is overtaken by an equally large lead bullet, because the counterforce of the air resistance (increasing with speed) equals the weight of the wooden ball (its downward force) much more than the weight of the lead bullet. In the case of the wooden ball, the smaller mass basically means that after 160 m, (or even earlier if you count the acceleration acceleration in the partial velocities to calculate the partial air resistances) and with the lead ball only after 2.6 km. Until these points their acceleration decreases steadily to zero, after that the speed is constant. The wooden ball of Galileï lost within a 100m of a tower so much of its acceleration already visible earlier.
Stevin had less trouble with two lead bullets. The small bullet from Stevin (with half of the wind-catching cross-section it is 10 times as light as the big one) would only reach that point after 1.2km. With a tower of 100m you can hardly notice that difference in starting acceleration reduction.
In any case, both have proven that a 10 times heavier ball does not fall 10 times faster.

The same is true for the Dutch invention of the telescope.
Galileï bought such a telescope from Middelburg and made a few improvements, so that the invention could be attributed to him.
These are two examples of widely quoted, incongruous, incorrect assumptions that persist for a long time, but this time to this day.

Useless conventions of printing, writing and publishing hamper reading
Another example of useless suppositions is the conventional way of publishing.

I can be mistaken, but there are some absurd habits in scientific publications that make me doubt the minds of the authors and publishers.
They are based on illusory scientific assumptions that create annoying barriers to reading and understanding.

For example, there is a custom to divide a list of keywords into categories, such as 'Persons', 'Subjects' (even subdivided in 'Latin names' and 'English names'), 'Bibliography, 'Used symbols', 'List of figures'. This results in unnecessary searching and browsing. It ignores the *alphabetical* function of an *index*.

Categorization is the task of the *chapter* names, summarized in the *table of contents*. The titles of the chapters should make clear at a glance what they are about.

Instead, the author often invents poetically concealing titles that force you to read everything to come to the conclusion that it is known matter.
Poetry offers a different perspective on the text, but it belongs to the end of a chapter or paragraph, otherwise you do not know what needs to be put into perspective.

The table of contents should be short and at the beginning of the publication or even on the cover in order to know what you are buying.

A further division of the table of contents as a first *summary* per chapter saves unnecessary introduction and extension. If the titles are not a summary or conclusion, then it is belletry or concealment of ignorance. Start with a conclusion. I prefer to see firm assertions as a title, then you become curious about how that can be defended.

Concealment in technical terms that can equally well be written in colloquial is pure fattening which I mistrust.
The author thinks it is interesting, but the reader drops out and goes on the internet.

If you want to prove your learning, or give access to literature, put those terms in parentheses behind the normal description. New words ('neologisms') or new spellings are crimes against retrieval when proper words already exist.

I am tired defoliating in endnotes and literature (sometimes even categorized).
I want footnotes, not numbered troughout the book, but again per page.

Butter at the fish, otherwise I have to go to the kitchen every time to get the salt, one time to the literature (where is it?), the other time to pages full of endnotes that are even also numbered per chapter (in which chapter did I read?).
That is how I already forgot what I was looking for.

Notes are useful, they create branches without interrupting the line of argument.
Put them to the *word* they belong to, and not according to that stupid convention at the end of a sentence.

Do that with characters, because numbers are exponents. Einstein^2 leads away.
One author (ten is pointless) with title makes a reference to literature already searchable, but Einstein (1905) is a person different from Einstein (1916).
That date should be at the forefront next to the author and not in the back.

The subdivision into chapters, subheads and paragraphs also allows branching, so that you can refer back to lines to which you want to reconnect.
Please, refer not only to a chapter number or figure number, but also to the page.
These page numbers must be large and appear on the outside of the page.

Branches are indispensable, but I dream of a language that allows itself a glance on all side streets, such as images.
Images can replace much text. Learn to draw, how much time that may cost.
It saves the reader time and attracts attention.

Some authors make me lose track of sentences and paragraphs that contain more than four lines. Give space, spaces, but no empty pages, no graphic decoration or lay-out that makes no sense.

§ 7 THIS STUDY IS A DESIGN

THIS STUDY HAS PERSONAL AND COMMON PREOCCUPATIONS

The conceptual preoccupations preceding the ABC-sequence of scientific suppositions in chapter 8, 9, and 10 entails not only what we learned in our childhood (chapter 3), but also some common roots of science: philosophy, logic and mathematics (chapter 5, 6, and 7). These fields precede the described ABC branches of science.

Chapters 8, 9 and 10 repeat not much more than what you may have learned at high school about physics, biology and humanities as designs. I will therefore not refer to the most recent publications about the subject, but to the oldest I could find. These may testify the moment of their invention. I assumed the author as the designer.

Which suppositions had to be changed at the time of their first design, is a subject of the history of science.
I will only check the (often hidden) suppositions now required for their construction.

In order to discover hidden assumptions, programming a computer is a beneficial tool. If you do not tell a computer everything from the beginning, in the right conditional sequence, it will not work. You should include all known suppositions, but even then, its hardware, its language and its software, may hide tacit suppositions.
As far as possible for me, I checked what I learned with computer calculations.

Calculations require explicit assumptions. Then they go their own way.
Their outcome does not depend of anything of what *you* want or expect.
You have to see how it works in order to understand it.[a]
What works is true here and now, but in another context it may be false.

Mathematics works, but I still doubt its hidden assumptions such as the possibility of exact equality and repetition.
Everything differs, if not in nature, then in place and therefore in circumstances.

The advantage of a layman's report is that you can leave fewer assumptions unspoken. You cannot leave anything out of the secret language of skilled experts with all their learned meanings and assumptions.

Yet it appears that the argument is not always longer, but often shorter.
Probably you go too short as a layman, but there is always a chance that you will omit professionally ingrained but unnecessary assumptions.
Experts who read my efforts smiling, I ask to let me know where I have misbehaved.

Even if I have misunderstood something, rectification allows me to shift the flow of constant doubt, to choose another path in the environment, to expose the surface there. The same sediment is everywhere. I doubt too limited, too superficial or too profound assumptions of language, logic, exact sciences, humanities and … of my own.

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a For the calculations I use Excel and for symbolic operations the freely available computer program Maxima (http://maxima.sourceforge.net/).

2 THIS STUDY REDUCES BLOCKING SUPPOSITIONS

Science was a beautiful design, but for half a century there has been little design involved if you compare it with the half century before. There are plenty of terrains with dilapidated ruins lying down for new construction on their old foundations or with new piles. Which unspoken suppositions hold us back and which do not?

THIS STUDY COVERS ITS OWN CONDITIONS OF DESIGN

Each of the chapters 4 to 10 will end with a template in order to check its design content and the hypothesis. Applied on this study itself reads as follows.
Fig. 7 p24 distinguishes modalities, levels of scale, context and object layers of design. This study then exhibits the following design features.

Modality⇓((true⇒probable⇒possible⇒imaginable)∧desirable)
Truth is bound to assertions in verbal language. The headers of this study are formalized as assertions to be defended in the text that follows. The reader should decide if they are **imaginable**, **possible**, **probable** or even **true**, and if so, **desirable**.

The images I made or cited cannot be true, since 'truth' is bound to assertions in verbal language. They may extend your imagination of possibilities (probable or not), *beyond* the linearity of verbal language. The ***desirable*** in this study is, to reduce suppositions of imagination in order to extend the diversity of possibilities by design.

Levels of scale⇓(…, 10m, 3m, 1m, …)
Changing the scale may change your train of thought. Paradoxes may appear putting an **object** in a **context** (***Fig. 6*** p18). A context may change the object and its borders. It may even change the meaning or significance of words, extending verbal language. It is a method to find unnecessary suppositions for design, the aim of this study.

Context layers⇓(Abiotics⇑Biotics⇑Technique⇑Economy⇑Culture⇑Governance)
Design implies the imagination of an object that does not yet exist.
The only handhold then is, an image of its future *context*.
The **Abiotic**, **Biotic** and (in a broad sense) **Cultural** context, and the different ways these are commonly or potentially imagined, is subject of chapter 8, 9, and 10.

This study accepts their eventually limiting effect on our imagination in one direction, but it stresses their unforeseen perspectives in the other directions (see ***Fig. 10*** p28). Abiotics *enable* (⇑) imagining Biotics, and biotics *enable* (⇑) Culture, after all. Without life, there is no Culture. This study narrows this broad concept of Culture.

It distinguishes **Technique⇑Economy⇑Culture in a narrower sense⇑Governance**. The primary position of technique (including design) should be explained.

The *knowledge* of techniques, *technology,* is doubtlessly part of culture in a narrower sense, but the worldwide *use* of common techniques became a self-evident material condition. Technique is an extension of our biotic abilities of senses, organs and muscles. It *enables* any specific local economy, culture and governance.

Such biotic abilities are themselves recognizable as techniques. Photosynthesis is a biotic machinery (***Fig. 205*** p229). The technique by which we move, look, and breeze are not part of a specific culture, but biotic abilities. Cars, televisions and mouth masks extend these abilities. Their *form* differs. That is 'cultural' in a narrower sense.

This study concerns economy, culture and governance as designed *contexts*.
That supposes an intention, function, structure, form, and content, once designed.
The technique of design then is a human ability, preceding economy, culture and governance, building on preceding biotic techniques.

What then is the *object* of this study as a design?

Object layers⇓(Content⇑Form⇑Structure⇑Function⇑Intention)
The **content** of this study is summarized in its index on page 299 and further.
The **form** resembles that of a tree: roots (chapters 0 to 7), a trunk (chapter 8, 9, and 10) and a crown (chapter 11, still in its infancy).
The **structure** is separation of branches, connections by conditions ⇓ or ⇑.
The **function** of each chapter is, to enable imagining the next one.
The **intention** is, to enable extending design beyond probability.

THIS STUDY OBEYS ITS OWN HYPOTHESIS
This study answers its own hypothesis ***Fig. 13*** p37:

A difference	⇑ change	⇑ coherence	⇑ selection	⇑ combination	⇑
B metabolism	⇑ regulation	⇑ organization	⇑ specialization	⇑ reproduction	⇑
C information	⇑ security	⇑ affection	⇑ identity	⇑ influence	

That hypothesis contains the previous modalities, levels and layers.
This study makes a **difference** between unusual categories of modality, levels of scale and layers of context and object.

This study makes a **change**, something different from 'now'.
Change includes 'zero change', continuity.
This study also maintains many usual concepts summarized in the index, but it places some of them in the different, larger context of possibility.
You may interprete that as a scale jump, changing their meaning.

That change of meaning can be paradoxical, but it becomes **coherent** in the image.
An image has more directions than verbal language. A contradiction may become coherent ⊥ the contradicting *verbal* assertion. Separation in one direction allows connection ⊥ the separation. Structure ⇓ coherence ⇓ continuity in change.

That structured image enables **selection**, and selection enables new **combinations**.
This study selects a few concepts, combining them in some new combinations.
Whether it will enable different combinations in your **metabolism** of concepts, enabling changing that metabolism by **regulation** and so on, you must decide yourself.

3. PHYSICAL MOVEMENT ENABLES IMAGINATION

§ 8 PHYSICAL MOVEMENT ENABLES LEARNING

I assume there is a world outside of me. It changes when I move. I do not share the solipsistic idea of idealists from Socrates and Plato onwards[a]. The world is not already contained in my mind. Continuously transient impressions provide me with news in a multitude and diversity I cannot contain, let alone make up myself.

That diversity must therefore come from somewhere else than from me.
This is all the more so, if others tell me to have seen, felt, heard or smelled something similar. If that is also different, then that only makes even more convincing that I cannot invent everything myself or have inherited it as an a priori.

From that variety I detach objects that look similar to each other (differ mutually less than from the rest), to hold them as an image.
But I often get new impressions, of which I have no idea yet.

How did you and I then learn to find our way in a constantly changing chaos of impressions (Piaget's 'tableau mouvant'[b])?
How did that start from birth and possibly even before ('prenatally')?

Science remains a human design, a reconstruction, a co-agitation (see note p18).
This chapter is not intended to rewrite conventional child psychology.
I acknowledge that existing scientific possibility to reconstruct the development of our thinking capacity, but there are other designs possible.

This chapter argues one of those other possibilities from the physical conditions at every stage of development as we think we know as adults.
It then argues which assumptions can be build on previously constructed assumptions.
Postmodern difference thinking did not yet succeed in this.[c]

PIAGET INTRODUCED MOVEMENT AS A CONDITION OF LEARNING

Piaget[d] has uncovered the importance of own movement ('motor skills') after birth.
His influence has been great, for example on education.

After his publications full of experiments with children, they got more gymnastics and sports scheduled and they were allowed to stand up from their chairs in the classroom without being asked. I was not allowed to do so yet.

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a For example Berkeley(1710)Treatise concerning the principles of human knowledge(Dublin)Pepyat: 'there is no object without a subject'.

b Piaget(1937)La construction du reel chez l'enfant(Neuchatel 1971)Delachaux et Niestle p6

c See for example Deleuze(1994)Difference and Repetition(New York)Columbia University Press.

d Piaget(1966)La psychologie de l'enfant(Paris)Presses universitaires de France I quote this publication here and in the following as Piaget(1966), because his other publications relevant to my purpose have been summarized sufficiently for the time being. You will find a complete list of partly downloadable titles http://www.fondationjeanpiaget.ch/fjp/site/bibliographie/index_livres_chrono.php (2016). The relevance is evident from titles such as: (1926)La représentation du monde chez l'enfant, (1927)La causalité physique chez l'enfant, (1937)La construction du réel chez l'enfant, (1941)Le développement des quantités chez l'enfant: conservation et atomisme, (1941)La genèse du nombre chez l'enfant Neuchâtel, (1942)Classes, relations et nombres: essai sur les groupements de la logistique et sur la réversibilité de la pensée, (1945)La formation du symbole chez l'enfant: imitation, jeu et rêve, image et représentation, (1946)Le développement de la notion de temps chez l'enfant, (1946)Les notions de mouvement et de vitesse chez l'enfant, (1948)La géométrie spontanée de l'enfant, (1948)La représentation de l'espace chez l'enfant, (1966)L'image mentale chez l'enfant: étude sur le développement des représentations imagées, (1966)La psychologie de l'enfant, en (1970)L'épistémologie génétique. I only refer to this in special cases.

3 PHYSICAL MOVEMENT ENABLES IMAGINATION

Previously, the psychologists tried to understand our mind primarily from sensory perception and association. The rest they attributed to innate facilities that apparently did not need an explanation (a kind of Dei ex Machina, axiomatic shyness solutions like the a priori's from Kant). After Piaget, however, some a priori's revived.[a]

The development of our imagination in the first two years is shrouded in mystery in the absence of expression in language and drawings.

From a moving child (Piaget's 'sensory-motor phase'), however, you can draw up 'action plans', schemes building on each other.
Piaget observed them, did wonderful experiments, then concluded stages in the development of that sensory-motor phase, and left it at that.

That is empirically pure, but in my opinion there are unspoken assumptions in his conclusions that seem to be unnecessarily a priori.
There is more learned than what we have words for as adults. Our words generalize. They have unspoken assumptions that children cannot yet have.

According to Piaget, mental images arise only *after* that sensory-motor phase.[b]
The stage of imitative games, is followed by symbolic games.
The used symbols get a meaning in the action, not yet labelled with words, but their use is a preceding condition for the language acquisition *and the mental formation of images*. For psycholgists, language is the beginning of the story.

Symbols (for example dolls) *resemble* earlier impressions (people and their actions). Only then, symbols can get abstract signs, such as words ('doll', 'human'), which refer to more similar impressions at the same time.
So, according to Piaget, those *symbols* are the forerunners of the mental *image*.

I'm going to reverse that.
If symbols *resemble* impressions, how can that similarity be perceived otherwise than by a previous mental image (re-presentation) that is laid over both cases (eg human and doll)? Only through a mental image, a prior impression (human) can re-semble (show less difference with) the later symbol (doll).

This also may apply to the imitative game. It requires the transfer of other people's movements to yours. The impressions of both (seeing and doing) are very different. Think of yes-nodding, no-shaking or 'day-waving': what you *see* doing is totally different from what you *do*. How do you explain that imitative relationship?

The question then is, however, how monkeys and parrots[c] can imitate too.
Do they also have a mental image as an interfunctional intermediary?

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a Samet;Zaitchik(2017)Innateness and Contemporary Theories of Cognition(The Stanford Encyclopedia of Philosophy)Fall edition https://plato.stanford.edu/entries/innateness-cognition/ Carey(2015)Theories of development In dialog with Jean Piaget(Development Review)Elsevier

b Piaget(1966)p69

c It has been discovered that birds also have enough brains to be able to think like primates (eg imitate?): Olkowicz(2016)Birds have primate-like numbers of neurons in the forebrain(PNAS)0613 1517131113

Do the totally different impressions of two eyes on each side of a horse's head also produce one combined mental image (representation) that can apparently 'work'?

However that may be, with the opposite assumption that there is already an image before it gets a name, you can make a conditional series of stages in child development different from that of Piaget.

AN IMAGE PRECEDES ITS NAME: VERBAL LANGUAGE REFERS TO IMAGES

You can interpret the experiments of Piaget and others differently and observe children yourself, avoiding to take any adult skills, concepts and words for granted.

Piaget takes the adult logic, physics and biology too much as a starting point, trying to find back *their* traces in the childlike expressions. But you cannot understand the development of a slug house checking at each stage what looks like our houses.
It is a blocking supposition to project such images back in the child's development.

Imagine the limited possibilities (conditions) in a newborn child. I do not suppose that at birth there is *nothing* inborn ('tabula rasa'). There is a neural system. Prenatal movement reflexes are visible and they are repeated. As soon as a child has success with something, it lapses in repetition. That's what adults do also, by the way.

I leave the conditions for that repetition and other skills (exercise), to the biologists, but repetition can be found everywhere in nature (stretching and relaxing of muscles, heartbeat, breathing, routines). Physicists also know the operation of a pendulum and of waves with their sinus movement. Repeating makes equal changes continuous: a scale paradox of change and continuity in time.

The primary question is: which representations of the world around you are possible at all in the first stage, and which conditions have to be fulfilled in succession, in order to build up more comprehensive images.

Only then you can ask Piaget's reverse question: what must have preceded the skills of maturity that you discover in subsequent stages, described in observations (such as that of Piaget and his successors) of subsequent phases.

In order to design a comprehensible conditional sequence, you have to alternate these two questions, starting with the first.
As a meticulously empiric, Piaget supposed nothing more than a 'tableau movant' in the beginning and then he concentrated on the second question reasoning backwards.

I will first reason forwards as a designer, in order to explore the possibilities of the newborn as soon as it applies and explores its new possibility of own movement.

MOVEMENT ENABLES A DISTINCTIVE ABILITY

I assume that after birth the discernment of *differences* is the first condition to see, feel, hear and so on, and therafter to imagine, to think and choose something (an 'object'). I therefore refrain from the habit of immediately thinking in categories.

3 PHYSICAL MOVEMENT ENABLES IMAGINATION

Words are general categories or classes. I cannot *express* my line of thought without words, but categories exist primarily through their mutual (external) *difference*, not the other way around (by its internal *equalities*).

With 'difference' you immediately think of the differences of some quality, as you perceive them looking or groping and represent them as well: color, shape, texture.

You can then add the impressions from other senses (sound, smell) to that quality. That starting point, however, always led me to discover that there were still unspoken conditions missing for future skills, for example difference of place or 'direction'.

If there is a constructable sequence in the conditions that allow us to distinguish differences of quality, then it is first of all necessary in advance, that you can distinguish *objects* in between which the difference occurs ('object constancy').

This requires the endless parallax exercises I observed so often. Parallax requires repeated own movements, but what does that parallax mean for the newborn?

MOVEMENT ENABLES A SENSE OF DIRECTION

You cannot suppose something as abstract as 'direction' in a newborn.
Direction is part of the practice of every movement, especially in the movement of your eyes. Once they are open, they have a view *direction*, but that may be just adult talk.
A newborn human cannot 'under-stand' (sub-pose) anything yet, let alone 'direction'.
It is nothing more than imagined movement.
Plants may move guided by sunlight, but they cannot leave their location.

Animals (like us) differ from plants by the possibility of free movement.
This movement is focused on fleeing, fighting or eating in order to survive.
In their movements numerous muscles must be coordinated simultaneously or in succession. What triggers and guides the effective muscles?

Perhaps 'thinking' is only a further development of that old capacity to coordinate partial actions in an inborn reflex, in a learned routine, or finally with a conscious image of simultaneous or successive actions.
Movement then is an evolutionary condition for 'thinking'.

Especially moving with your eyes is impressive. It changes the whole world, while the previous world is still afterglowing. That must be incomprehensible in the beginning, but it is a self-generated, all-encompassing sensation of difference.
As adults among each other, let us call that 'difference of direction' for the time being.

MOVEMENT ENABLES LEARNING

Movement remains crucial in every subsequent phase. As adults we can release and quantify something like speed: distance d divided by time t (d/t).

We express it, for example, in the number of kilometers traveled per hour.
If you include the mass m, you get an even more complex concept: 'amount of movement' (m*d/t, 'impulse'), and both have a direction ('vector').

If they both have a direction, why should you distinguish between movement and direction as a baby? Direction is at most an animal feeling of 'forward!' or 'get out!', possibly connected with, and qualified by, desire and fear. The only result of your movement is a difference, and that is noticeable with all senses.

There is still no observable distinction between d and t, 'distance' and 'time'.[a]
You only notice their quotient when you bump to something.
'Nice' is, if the value of that ratio is low (so, laugh), otherwise 'pain' (so, cry).

Consciousness of differences in 'mass' only comes when you start handling things, and 'space' or 'time' come even much later. Movement ⇓ change, a difference with now.

Everything is 'now', with an after-image in your eyes, an after-feeling on your skin (pain!), a reverberation in your ears, which only *differ* from the current impression.

Memory is no more than an after-image yet, and that is also 'now'. Later you have to learn from gurus again, to unlearn stress. Regret? Care? Nonsense all. Adult talk.

a Einstein regarded speed as a primary quantity, of which space and time are derived. He seems to have asked Piaget if you have to suppose a sense of time in children before they could develop a sense of speed with the help of that. In this way Kant's a priori of space and time would be refuted. The fact that children initially do not distinguish space and time in a movement seems to follow from a note from Piaget (1966) note p67 in the Dutch version: "Like some primitive painters, the child will indeed try to realize the chronological development in a single drawing: sees, for example, a mountain with five or six males, while it concerns a single person in five or six consecutive positions."

3 PHYSICAL MOVEMENT ENABLES IMAGINATION

§ 9 A SENSE OF DIRECTION DEVELOPS AFTER BIRTH

A FRONTAL FOCUS DIFFERS FROM A LATERAL PLANE

Directional distinction in frontal focus (forward from the observing and thinking subject), differs ⊥ from directions in the plane on which images are projected (the retina or the skin). I will call these directions 'frontal' and 'lateral' respectively.

When you change your focus frontally, then you see something change laterally. You can scan the lateral plane in arbitrary directions, until a boundary (continuous difference) appears. You may recognize it from previous impressions.

Without a connection with your own frontal movement and view direction, you cannot yet understand that lateral change of your image.
Every ability to distinguish requires a sense of frontal and lateral difference in direction. That awareness should have its origin in the senses.

Moving into an object, requires a complex coordination of muscles and some awareness of different directions, but these are distorted by perspective.
Animals can orientate themselves too, and sometimes even much better and faster. What then is our advantage?

Perhaps we can imagine more directions than 'forward!' or 'get out!'.
In any case, I cannot imagine a length, surface, content, form (in short: space and its geometry) without a primary distinction of differences in direction.
I even suspect that any distinction requires a distinction of directions.

ALL SENSES ARE DIRECTION-SENSITIVE

A prenatal directional sense is probably of no use. It therefore does not have to develop in the embryo. In the mother's belly it probably has no other direction factor than gravity, and there are no tangible differences in pressure distribution over the swimming body.

It is conceivable that other senses such as hearing, smell and taste do give prenatal impressions, but they do not have to be direction-sensitive yet.[a]

What is the contribution of different senses to our directional sensitivity? I do not know which senses become operational successively after birth and in what proportion their influence on the sense of direction then develops. So the order below is arbitrary.

The touch, pain, heat and cold sensitivities are probably the first (already at birth) and the most impressive sensory impressions. They are mainly localized in the skin. How do they contribute to the primary directional sensitivity?

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a A nice example: Clombelli(2016)Vocal imitation of mother's calls by begging Red-backed Fairywren nestlings increases parental provisioning(The Auk Ornithological Advances)Volume 133 p273–285, http://americanornithologypubs.org/doi/full/10.1642/AUK-15-162.1 shows that birds learn the songs of their parents already in the egg.
According to Piaget (1966), repeated reflexes (such as exercising with the gripping ability of the hands) are prenatal preparations for the 'outdoor life' that will develop after birth to more complex habits (such as targeted gripping), adapting oneself (physical adaptation, not just intellectual association) to the new demands of the postnatal environment.
For my argument it is important that of the prenatal reflex rhythm, repetition of once effective movements remains as a habit. Repetition is then a priori innate. It occurs everywhere in nature. For that I do not have to look for any reasoned conditions.

Adults can pinpoint the stimulus place. They are place-conscious, but in newborns you do not have to assume that. It is conceivable that newborns only have an unconscious avoidance reflex that automatically follows an opposite 'flight direction' of limbs, body parts or the entire organism.

Without the ability to crawl or walk, the ability to move is not yet fully grown.
It cannot contribute otherwise to the sense of direction than moving eyes, head and limbs. Whether the awareness of body polarities (front-back, left-right, top-down) already plays a role in such an avoidance reflex is also questionable.[a]

In adults with all movement possibilities and their upright gait (with a clear top and bottom), such a notion has the role of coordinates by which the stimulus (threat or attraction) can be localized and a flight or approach direction can be weighed.

The hearing is in principle direction-sensitive due to the placement of our ears.
I do not know at what stage that difference in direction between the two can be made out of the child's reaction. Sound directions can probably be associated only later with other impressions on the left-right polarities of the body.

It is clear that the unique designation of 'left' and 'right' due to the symmetry of the body takes a long time (at least I needed a mnemonic for a long time: 'right is the side by which you write'). *Making a sound* is directionless, but it does give a first effective influence on the environment. So you will repeat it (cry!).

Odor sensitivity can be decisive in animals.
Butterfly males can find a female at a great distance due to the concentration gradient of her scattering fragrance ('pheromone'). The role of odorants in humans is insufficiently known to me, but it is conceivable that it brings the newborns on the trail of their mother, such as kangaroo-embryos look for the pouch.

Something similar can be assumed for **taste sensitivity**, which at the same time as the sense of touch of the hands, lips, mouth and tongue, arouses attraction or disgust.
The tendency to put everything into the mouth and make it 'own' that way can be more difficult to associate with sense of direction, perhaps with the body polarity in which mouth, nose, eyes and bringing the hands to the mouth point in the same direction.

Due to their variable direction of **vision**, the eyes orientate without any other movements from the moment they are open, even though this can already be prepared by other senses. Direction could then be an important factor in the integration of impressions from different senses ('synaesthesia').

Any change of view has very different impressions as a result.
To be able to change these impressions yourself should be an enchanting impression, (if there is at least something different in the environment[b]).

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a Sinnott(1960)Plant morfogenesis(New York)McGraw-Hill, distinguishes very illuminating in all living beings 'polarity' as the first principle of form alongside (perpendicularly) symmetry, and (wrapping around it) spiral formation.

b In an orphanage with foundlings who spent a long time in bare spaces with few stimuli, a relatively high mortality was observed:
Spitz(1945)Hospitalism An Inquiry Into the Genesis of Psychiatric Conditions in Early Childhood(Psychoanalytic Study of the Child)1, 53-74.
Dember(1979)The Psychology of Perception(New York) Holt, Rinehart & Winston

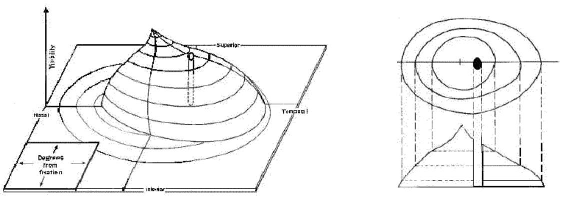


Fig. 14 Visibility from the center[a]

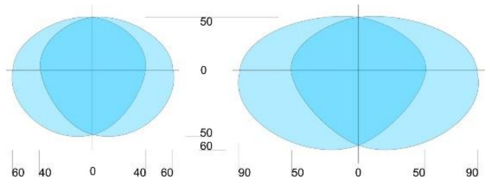


Fig. 15 The field of view of children and adults (in degrees from the center)[b]

The center of the eye, with the highest concentration of cones (***Fig. 14***), produces the most detailed and color-sensitive part of the image.
The surroundings of the center will decrease from there in color and detail.
The biggest differences of brightness and color (contrast) attract attention, focus.

For adults, eye movements are difficult to make gradually (just try it). They lead jerkily from one object to another. Compare the sudden head movements of birds, probably giving time to assimilate separate impressions. Directions and corresponding impressions then can be clearly distinguished. Newborns may not yet distinguish objects, but surfaces with the greatest differences in color, clarity and detail.

The field of vision of children is smaller than that of adults (***Fig. 15***), but it can eventually be extended with head and eye movements by intellectual composition to a 'panoramic' image.

In the beginning, you do not have to distinguish the various impressions by your own eye movement from the changes in the image itself.
In other words, you do not have to suppose a distinction between space and time.

This only becomes topical when you learn to distinguish between what you can do yourself (different impressions), and external changes that you obviously cannot influence (unless you can magically conjure, a wish fascinating every child later).

That is also the painful moment when you have to make a distinction between 'me' and the rest. In other words: if a solipsistic 'all' clearly breaks apart your own movements from the arbitrary movements around you. Piaget calls that 'decentralization'.

You cannot assume depth perception in the beginning, although the stereoscopic image with two eyes is self-evident for adults. Animals with eyes on the sides of the head may also not directly construct a stereoscopic image. The first impression is as flat as the retina or skin that passes on the differences. Perspective is constructed from two very different images, supplemented with movement.

'Distance' then only relates to directions in the lateral image plane and becomes plausible from differences in direction of te eye. The frontal distance between the observing subject and an object is probably associated with the lateral image much

a Anderson, D.R. (1984) Testing the field of vision (St. Louis) Mosby http://www.msac.gov.au/pdfs/reports/msacref13.pdf http://www.msac.gov.au/pdfs/reports/msacref13.pdf
b http://www.shef.ac.uk/personal/l/lgf/visiondeaf/ ; http://home.zonnet.nl/jcamps/gezichts.htm

later. With that, you can finally also make an objective image of yourself as an object in the midst of surrounding objects ('self-objectification').

Own movements of head and body (motor skills) enable a construction of depth in the image by lateral parallax and a frontally disappearing foreground against a staying background by crawling or walking.

Grasping tangible and apparently still elusive objects in the image, the motoric insight of depth is rewarded with the sense of touch.
Appropriation (putting it in your mouth!) gives direction and grip of hand movements.
Grabbing to elusive objects changes to 'pointing with a finger'.
This finger pointing occurs before (and is an important condition for) language development. It is the first sign of 'referring'.

It is conceivable that **other direction-sensitive** senses have been developed in the animal and plant world, such as the orientation of migratory birds, the orientation of plants on the sun, and so on, but I assume that these have a subordinate role in people with highly developed other senses.

So, directional distinction can be made by all sensory impressions.

§ 10 OBJECT⥣SEQUENCE⥣SIZE⥣DISTANCE⥣PLACE⥣QUALITY

'OBJECT' SUPPOSES DIFFERENT DIRECTIONS

'One' (object) enables a logical 'no', refusing and wanting

If parallax exercises allow you to permanently separate a moving part in the field of vision from its background ('object constancy'), then the first substantial spatial difference emerges: object and non-object.

The sense of direction stems from different senses. It enables targeted gripping. If the object is also accessible and tangible, then you will get a proper 'grip' on the object.

'Com-prehension' (prehension is 'grip') supposes separating a self-made representation from the impression. You can remember, re-present (make present) the object without input from the senses (imagination). This imagination, however, is a strong reduction of the first impression. From that information you have demonstrably made aware very little.[a] There remains only a tiny part in your memory.

Many elements associated with that impression (smell, sound, context), however, can remain associated with the representation of the object.
With a next impression, a similar object is 'redefined' and if apparently necessary, the representation is adjusted (expanded or limited).

In the impression itself, the focus and attention on the object is concentrated, while the rest (non-object) in the outwardly fading periphery remains largely undetermined.

Object constancy then is a necessary condition for the development of another ('logical') concept for that indefinite rest (the denial of the object): your first conjunction 'not' (although that does not yet have a name).
That makes refusing possible and wanting of what is *not* there.

If an object disappears behind something else ('in the nothing') and then reappears (the essential game of 'peek-a-boo'), then there is a moment of indeterminacy (loss, hope, expectation?), upon which resurrection is resolved by recognition (relief!).

This recognition after a short disappearance is initially not yet essentially different from the recognition of appearing and disappearing images that you pass moving and re-appear looking back.

The first object you notice in this way is probably your mother.
Primitive memory mainly stores what is useful for survival (food and care).
That can be sobering for adults.[b]

Adults mainly think to be seen as 'human' by babies, but that may be an illusion until the second year. We may be no more than objects that may or may not be wanted.
I observed that the eyes of a one year old child continued to look straight ahead, while

a According to Silbernagl(1991)DTV-Taschenatlas der Physiologie(Stuttgart)Thieme p274: less than 0,00001%.
b The answer of two children at the age of two who were able to answer on my question "What is a mother?" was: "Big and warm". See also Piaget(1966) p28 in the Dutch version.

my head passed her field of vision. She even laughed with pleasure, but not at me. Probably she was still only fascinated by the change of background at the more permanent foreground of my head (parallax).[a]

You must already have that stage long behind in order to be able to distribute your attention to more than one object.
If two objects move in different directions, you can no longer follow them in one go.

'Two' enables decentralization of the individual
In order to distinguish a second object from this first object, requires a further kind of distinction: *difference of object*.

For example, to be able to distinguish mother and father from a distance, requires more coupled associations (soft, warm, drinking! or moving, news, frolicking![b]).
That requires a more advanced pattern recognition than parallax alone.

A second object claims its own focus, added to the image that you have just released from the first object as a memory, incorporated within your own (solipsistic) unity.

If they are similar, you can still experience that as movement, unless they move in different directions. If they differ in character, then that second focus is no longer part of that unity, there is something else. It is 'no', but not 'nothing'.
The unity in which everything is yours may fall apart.

This ⇓ room for more 'memory places' than the one immediatly recording your own recent movement. That increasing memory space may be occupied primarily by the *succession* of reduced impressions, a primitive 'past'.
Being able to crawl and walk creates a new revolution in imagination.

This experience of own movement through different places enables an awareness of *sequence* corresponding with the sequence of impressions.

The subject 'me' ⇓ a centre in which all directions come together.
The primitive past, the sequence of recent impressions and objects may disturb that unity of the subject with its once observed and incorporated 'own' object.

In adult terms it raises the question 'was that me?', because that imagined past is no longer the actual centre. That 'decentralization' requires a 'subject constancy' enabled by *sequence* of movements on your own initiative.

At a later stage you may restore the unity also summarizing and remembering a series of *similar* objects as an object on itself (set).

a 'I remember my niece celebrating her first birthday. Grandma held her on her lap saying "Quiet my darling, quiet!". But she stayed crying all the time kicking her legs. I had been reading Piaget recently and said: 'Give her to me'. Grandma handed me the child and I helped her kicking legs to move her body up and down to see my face alternating with the background. She started laughing! Grandma, somewhat embarrassed, thought she loved me more than her, but I explained her the baby was experimenting parallax: changing object and context by moving up and down. She did not see me as a person, she tried to understand the difference between my face and my background first. That is why moving on a swing set or a seesaw is so fascinating for children.' Jong(2005)Child perception(Delft)Contribution ChildStreet Conference 26th of august

b Excuses for the stereotype of the parent role of wife and husband that seems to be expressed here.
I do not know the difference a baby may observe, but this example is only meant to indicate that once any *difference of object* should be observed.

That is another kind of order than sequence. That set may once get a name (a denominator), to be manipulated co-actively again on your own initiative.

However, *different* objects can only be summarized if they share the same *place* of one impression, but the concept of different 'places' requires suppositions that have not yet been constructed as a concept. 'Different objects' still cannot be 'placed'.

Objects that do not obey your own movements should get their own place, but then they are no longer 'yours'.

'Three' is an innate limit
After Piaget, Feigenson and Carey(2005)[a] discovered that a baby shortly after birth can distinguish sets of 2 and 3 elements, but not of 3 and 4.
So, 3 is an innate limit, but a third object in the image enables the construction of next numbers. In general, it enables human thinking at all (p31).

'SEQUENCE' SUPPOSES DIFFERENT OBJECTS
Repeatedly moving yourself along the same series of different objects, repeats impressions in the same order. Own movement combines the sequence 'in time and space' still without any abstract distinction between space and time. From these repeated impressions you can detach and use the repeatedly observed sequence.
This will enable later numbering and counting.

Sequence then can be associated with (and transferred to) *actions* such as crawling and walking. With this, people can finally see a series of actions of which only the first is directly feasible and only the last satisfies.[b] Only the *number* of intermediate actions (such as making tools and using language) distinguishes people from animals.

At this stage, it may be useful to play with animals, because children can identify with their arbitrary behavior without intermediate actions worth mentioning.

As soon as they recognize the sequential arbitrariness of their own actions that they still see in animals, this association contributes to their identity (distinction) as a human being. Playing with animals introduces the human 'third action' in the game, a goal extending the series of two actions (eg throwing a ball extends the dog's routine of 'run and catch').

'Sequence' later enables language use and calculation.
In the opposite direction a series of words loses its meaning.

Any *qualitative* consideration supposes a series (from low to high valuation) that can fill simple black-and-white thinking with nuanced intermediate values.
Every *quantitative* assessment will also suppose a series (from small to large or from little to much).

a Feigenson;Carey(2005)On the limits of infants' quantification of small object arrays(Cognition)97 295–313
b A earlier mentioned demarcation criterion between humans and animals according to Harrison(1970).

I cannot imagine a sequence of objects without 'direction'.
Sequence supposes objects and a direction. An image, however, has a story in all directions. That gives rise to different stories, and therefore widens imagination.

'SIZE' SUPPOSES DIFFERENT SEQUENCES
In the lateral image, the difference of size is relative.
One object fills the field of vision more than the other.

The impression of a small remote object also increases when approaching.
This happens in a fixed order from small to large, but these seeming changes in size still stand in the way of an awareness of absolute size and distance.

An approaching or approached object eventually becomes tangible. That gives a hold.
What comes within reach is first given two absolute values.
Handable objects are 'small', non-manageable are 'big'.

With the 'growing up' itself, intermediate values arise of less and more manageable objects, associated with their own efforts as 'light' and 'heavy'. The focus is naturally on the largest, most screen-filling object, but that also offers the greatest chance of unmanageability. The boundaries of manageability are explored and shifted.

This creates a feeling for the order of sizes between manageable and not yet manageable. It must be a fascinating experience to be able to handle ever larger objects, such as 'larger ones' can. 'If you are big, you can do everything.'
There are 'smaller' and 'bigger' brothers, sisters and friends. Many qualitative associations are linked to this self-evident order, but size becomes distinctive.

'DISTANCE' SUPPOSES DIFFERENT SIZES
Distances are distorted in perspective in our visual image.
They also change with movement. How do you construct the absolute distances between the objects in your environment from that relativity?

Own movement lets objects disappear sideways from the field of view, while the frontal object of focus fills the image until it is tangible.
The laterally increasing distances in the image (widening, removing and disappearing) must be related to the progressively decreasing distance of approaching (from unreachable to tangible). Both suppose a sequence.

To make that connection seems a difficult task, but that ⊥ coordination between frontal and lateral is a prerequisite for a 3D concept with absolute distances in different directions. Only in this way objects do acquire a unique and mutually determined place in space. This also gives stereoscopic vision (in fact an inborn constant parallax) its spatial content.

'Distance' in the lateral image initially may be no more than a difference in viewing direction. 'Distance' in the frontal direction is initially only the difference between unattainable and tangible. 'Inaccessible' is 'not tangible', but approaching bridges that contradiction by one's own effort. Own locomotion relates both to each other, through the advancement with respect to laterally passing objects.

If all of them have disappeared from view, only the forward object remains, and finally becomes tangible.
A reminder of sideways disappeared objects gives intermediate values between unreachable and tangible as 'almost tangible' ('I'm almost there').

The geometric concept of 'distance' itself, however, is still difficult to understand. After all, it can only take meaning in the abstract 'nothing' between the objects. That object-negative 'nothing' is only determined between objects. Jigsaw puzzles do establish a connection between object and missing object (non-object).

By filling up, a void is given the dimensions of an object.
Jigsaw puzzles with pieces of different sizes and shapes would practice the concept of absolute distance in different directions. Jigsaw puzzles with pieces of the same size require other additional impressions (shape and color).

You can also fill the 'nothing' between objects, by grabbing them and bringing them together, stacking them, or colliding them with a blow (associating hard or soft sound with your effort). Conversely, you can throw an object out of the box.
That makes the frontal distance larger and the object smaller, but also unreachable and intangible until it is returned by someone.

Clashing and throwing may be important experiments to understand the relationship between frontal distance and size. The relation with distances between laterally passing objects is thus limited to relative (topological) relationships, but their geometric distance can already have some content due to a prior awareness of size. Absolute distance requires more insight into difference of place.

'PLACE' SUPPOSES DIFFERENT DISTANCES

Difference of location is only a lateral distance for two objects.
Only with a third object that simultaneously fills your field of view through frontal movement you can develop some understanding of place.
The objects that you pass get an increasing distance to the left and right until they disappear and only the central object remains in focus.

It requires, however, a representation of, and a memory for those objects (and for the effort to pass them) in order to be able to relate their distance apart from you to the distance to the frontal object of focus before you.
Probably looking sideways during your own movement is crucial.
A laterally disappearing object then appears for a short time between the objects that you passed and will pass, until you continue the route to the one in front of you.

The difference of place becomes real (associated with your effort) when you crawl from object to object and return with a sense of recognition to the original object. There you have already chosen a direction, the focus on a next object.

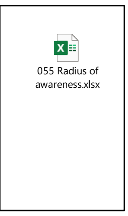
Arriving at that second object, you choose a different direction, a different focus on next object, small at some distance, but big when you have arrived on the spot again. Repetition is again the mother of the representation.

In doing so, you have gone through all the conditions for positioning in the previous sections several times.
When you have arrived at an object, you see from there the other objects in the usual perspective, but now with a motor reminder of the distances that separate them.

It is the beginning of locating with an anchor point ('origin'), and the primitive precursor of every route to school, work or recreational purpose that starts at home and ends at home with an increasing range (***Fig. 16***).
From that anchor point, directions, objects and sequences can be chosen, sizes and distances can be understood and places determined.

That does, however, not yet yield the abstract image of a map seen from above. This is only inspired by symbolic games with reduced models such as a dollhouse or buildings you made yourself with toy blocks, so that you can see it from above.

A place is not yet an abstract point (location) in the beginning, but a place with a boundary ('frame') and with smallest perceptible details ('grain'). Each place differs from the outside, but that difference is only recognizable from memory if their composition of details differ: differences in quality (that is not the case with points).



years old	m radius	area of awareness
0	1	Action space
1	3	Room
3	10	House
5	30	Yard
7	100	Neighbours
9	300	Neighbourhood
11	1000	District
13	3000	Town

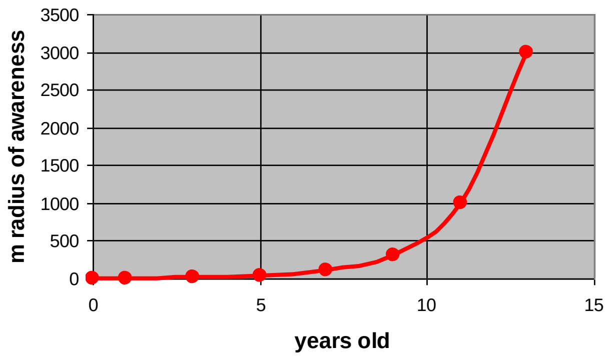


Fig. 16 Estimate of the increasing area of awareness by age[a]

By repetition finally every object becomes an anchor point from which location determination can take place: the bed, the bath, the dining area, the play corner and so on. They all have their own perspective, and their own familiar variety of impressions ('atmosphere') that no longer surprise us. They differ in quality.

Including objects outside the current field of vision in that primitive representation of place, requires a further development of imagination. The not directly perceptible must be included in the representation in order to find the bathroom and the bedroom

a Jong(2005)Child perception(Delft)Contribution ChildStreet Conference 26 august 2005http://www.taekemdejong.nl/Publications/2005/Child%20perception.doc yourself. The radius of action, initially restricted to the field of vision, will gradually increase with age until the mind is ripe for the abstraction of a map (***Fig. 16***).

'QUALITY' SUPPOSES DIFFERENT PLACES

Nothing can be distinguished without a difference of location.
That difference is determined externally by the own movement that was already central before, and internally by the increasingly sophisticated observation of differences of 'nature' (quality), of the objects that are permanently in that location.

You crawl to your focus object, and all objects around it (a collection) disappear left and right one after the other, until you see only one object, which you can then touch and grab, your doll: laugh! Your parents pick you up and let you take a step back to eat: cry! Taking distance is literally abs-traction. What we call 'scale' is frontal distance for you, varying between tangible (doll) and unreachable (play corner).

With increasing distance, the objects that you passed through are fading into one homogeneous object in one place: a collection or set. You can no longer distinguish the order, size, distance, place or quality in which they appear. The distinction between multiplicity and unity is not yet more than the operation of approaching and removing itself. The broadening of the field of vision that is associated with distance-taking gives room for more collections: the people, the room, the trees outside. These have become objects that you can capture and remember in one representation.

At the table, your collection of 'toys' ogles. Now suppose you have a doll and a bear, but your neighbor also has a dino. Apart from that dino, there is something different between your toys and the collection of your neighbor. If you can later make the sounds they call language, then you'll tell them you want a 'dino', or 'something else', or 'more' (then that doll and that bear), or ... 'three '.

There are, of course, many experiences in a child's life, in which an extra object has its own designation and is 'something else' or 'more'. How do you make the step, after the necessary repetition of such an experience, to replace that particular term with a word that has nothing to do with those objects themselves, such as 'three'?
How did you first get the idea to separate that *number* from three objects?

This happens when it concerns 'equal' objects.
After all, these no longer have their own distinctive quality or name.
You get that indication from older people who make different sounds each time with the next object. They get names in successive order. You could repeat actions before your birth as a reflex, so why not also make successive noises?

You hear adults making a *different* sound every time, even if they point to *similar* objects. It defines repetition itself. Birthdays now can be counted on your fingers.

You can 'number' them, *make* a difference where there is no other difference than a difference of place. To be able to 'count' you must also include the *set* of objects on a different level of scale within your image of one case. The total number of elements in that set is simply indicated by the triumphant sound by which the numbering ends. That representation as a set is a form of *abstraction*, taking distance, changing scale.

If sets only differ from place to place, then there may be only one quality left for discernment: the difference in that 'number' of elements ('cardinal number'). Beyond visual differences in density, that *number* is independent of the *physical* size of the set. The *abstract* size remains the same if you gather your dispersed marbles. If that number is the same in different sets, you can multiply, counting equal sets.

I will not elaborate furter the conditions for advancing mathematical insight (the distinction of numbers other than natural numbers, with operators other than addition and multiplication). What I wanted to demonstrate is achieved: 'number' ⇓ a last remaining quality of sets that no longer show any other difference.
Quantity ⇓ quality. Counting is the language of *equality* and repetition *within* a set, but *different* from *other* sets.

'Variables' suppose external (mutual) difference and internal equality
The abstraction of numbers into *variables* can sow life-long confusion and be a barrier to a career that requires mathematical skill. "A variable can be any number," says a teacher, "and another variable as well." Whatever else (s)he is going to say, here you have lost everything: 'the same, but not the same'. (S)he could better introduce variables simply as *words* (nouns or names) distinguishing different *kinds* of numbers.

Variables are words, although you may write them as an abbreviation.
Words such as 'animals' also refer to all kinds of animals. You only say 'this is an animal' if you still do not know which animal it is, let alone *how many* more there are. 'Plants' is then another variable with a different *quality*.[a]
Any quantity ⇓ a quality before you can count it. Regardless of any number you have to distinguish *different* quantities with *different* qualifications, named as *variables*.

a This seems contrary to Tarski(1914)Introduction To Logic And To The Methodology Of Deductive Sciences (New York 1941)Oxford University Press. On p4 he writes: "As opposed to the constants, the variables do not possess any meaning by themselves." This may be true 'by themselves', but the reverse is true 'mutally'. Variables such as speed v, distance d and duration t certainly do have a meaning, expressed in a formula such as v=d/t. They can function as words in a mathematical sentence with the operators as verbs. This is a clear example of the paradoxical opposition between a view from inside or from outside, defining a set by internal equality or external difference. 'In itself no meaning' may mean 'numerically no meaning', but even then the variables have the meaning 'a not yet determined quantity' different from another 'not yet determined quantity'.

4. A VERBAL LANGUAGE IS LINEAR

§ 11 A VERBAL LANGUAGE SUPPOSES A VERB

GRAMMAR SUPPOSES CONTENT

Linguists assume that grammar can be studied separately from meaning ('semantics') and, regardless of the content, represent an inborn logic.[a]
Meaning, however, has been supposed already in any grammar.

Without difference in meaning between nouns and verbs, variables and operators, grammar, symbolic logic or mathematics are not possible at all.
Conversely, designating a static or dynamic object by a meaningful (shared) name does not necessarily suppose a grammar.

This semantic premise does not only apply when speaking *about* grammar (in meta-language). Also in everyday speech, the choice of words demands a semantic distinction between noun and verb, before they are more precisely filled in (specified, declared, with adjectives and adverbs more precisely defined) and before they are put in a sequence and structure, understandable for others. Their interpretation with generalizing words also remains a generalization. Only proper names are specific.

That prior semantic distinction plays a crucial role in the determination of the correct grammatical order and thus in the choice of the first word of a sentence. This is apparent, for example, when someone searches for words under pressure or confusion and starts with 'I ... I ...', knowing that a verb must follow to be understandable.

A VERB IS NOT A RELATION, BUT AN OBJECT SUPPOSING AN ACTION

A verb is an independent word that *may* have relations with other words. As an operator, it is also a real object of action[b], an expression for the change in an often unspoken state of affairs that you want to communicate. The expression 'Go!' already has an understandable meaning for every audience without any further explanation.

You may imagine a changing 'state' of affairs as 'stable' for a while, naming it by a verb.[c] It is possibly restricted with other word types, but the verb is the most relevant object to communicate with. Even if your impression concerns 'no change', then you can describe this 'zero change' with a verb ('be', 'have' or 'stay').

That operator is not a 'relation', but an action object that can have relations with surrounding words. These relationships are determined by an agreed word sequence and proximity (grammar). This suggests first of all a causal relationship with the actor and subsequently eventually an *impact* relationship.

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a For example Chomsky(1971)Syntactic structures(The Hague)Mouton chapter 2 The independence of grammar p13.

b Our imagination supposes self-action with every representation you 'make'. Every object of attention is actively established. It is therefore plausible that an object is primarily identified with that activity, before it is stabilized in a memory, made retrievable (action) and possibly expressed in words (action). Attention primarily focuses on changes in the external environment that initially has no other analogy in our imagination than our own action and can therefore be remembered and possibly put into words as 'action'. In that sense, 'action' is an object. It can be remembered as an action. It is the co-action of which we primarily remember motor skills, just as a violinist can play the rehearsed music without having the notes in mind. In my opinion, this motor memory, in which many muscles have to be coordinated in a learned neuro-physiological scheme, is the precursor of every memory and imagination.

c Leibniz(1663-1716)Kleine philosophische Schriften(Leipzig1879)Koschny, XXV. Fünfter Brief von Leibniz an Herrn Clarke. 1716. p221 says rightly: "Streng genommen ist es richtig, dass kein Körper vollkommen und gänzlich in Ruhe ist, aber man sieht bei einer mathematischen Betrachtung der Sache davon ab."

An effect relationship with a result or direct object of that action is not even necessary to be able to form an intelligible sentence (for example 'I go').

The linguistic distinction subject - predicate conceals the indispensable and crucial *verb* primarily related to the *subject* in action. In a phrase, a primary relationship is wrongly established between the verb and the *result* of action or affected object.

Even the primary relationship with the actor does not have to appear in a sentence. It can be supposed tacitly.
The statement 'Go!' has an implicit actor: the addressed subject. Grammatically dressed-up into a full sentence it would read: 'You must leave.' 'Must' is an auxiliary verb of modality, with which the statement is said to belong to the modality of the desirable. In the form 'Go!' it is unspoken supposed and it sounds harder (shorter).

MODALITIES DISTINGUISH REASONING ABOUT TRUTH, POSSIBILITY OR DESIRABILITY

'Can' brings the statement into the modality of the possible ('potentialis'): 'You can go'. 'You go' is a description (whether or not true or probable). Without an auxiliary verb, this modality of (un)truth or (un)probability is usually assumed in verbal language.

The 'singing' or 'call' of birds is perhaps in the modality of the desirable.
If it were not a direct expression of emotion, but a description of it, then that description requires more distance from a direct physical intention than imaginable in birds. The 'singing' of birds obviously has the double meaning of luring and chase away ('come' and 'go'). The lure is meant for the partners, the simultaneous expulsion is meant to mark a territory against competitors.

The 'call' usually concerns an alarm cry probably with the meaning 'Go away!'.
The barking of dogs also may have a distance-increasing purpose, but the intonation and body language (especially the tail) can also mean other desirables such as submission (tail between the legs).
Cats have more tonal possibilities of expression (spinning, growling, screaming, meowing in different keys), but even then the tail is an important bearer of meaning.

It seems likely that babies also primarily express themselves in the modality of the desirable (crying and laughing). The first learned nouns (such as 'mom!') would then primarily mean the distance-reducing 'come here'.

A VERBAL LANGUAGE SUPPOSES VERBS

A sentence that is expressed or read in the opposite direction loses its meaning. Unlike the language of a two-dimensional drawing, a verbal language is linear and tacitly supposes a time direction or succession. There is no message ⊥ to the sentence direction. The meaning itself is bound to a time sequence. Each next word limits the scope (extension) of communicated meanings to an increasingly smaller set.

A drawing can be read in all directions and every route of the infinite number of possible routes delivers a story. Crossing and even parallel stories can contradict each other. For example, in one direction you can truthfully say: "The road becomes wider", and in the opposite direction: "The road becomes narrower".

A verbal language supposes first of all verbs (objects of change) and (pro)nouns (objects of difference, including the subject). These are the primary carriers of meaning. Other word types mainly specify or connect them. A verbal language supposes also commonly accepted sequences of words, enabling communication.
If you violate the sequence, then the meaning may be lost or changed. For example: "A calls B" versus "B calls A.".

Mathematics requires additional specification of sizes, distances, places and qualities. The resulting representation of differences of quality makes the distinction between sets possible.
The handling of overlapping sets requires a logic that is supposed in mathematics.

Logic concerns only conjunctions (or, if, and) that dissect or merge overlapping sets in their components. Conjunctions join. Such operators can be replaced by verbs.

They represent an action taken to obtain a result. For example 'A or C' may be replaced by '*Add* a set A to C without overlap', and 'if A then C' may be replaced by '*Subtract* from C non-A' and so on.
Something similar applies to mathematical operators (+, -, ×, etc.).

FORMULATING SUPPOSES DIFFERENCE OF QUALITY
So far only a conditionally substantiated reconstruction of a *possible* development of human discernment is outlined without empirical pretentions.
In the following sections 'difference' simply means 'difference of quality', regardless of how people have learned to distinguish that difference.

From such differences we derive categories, external impressions of internal equality in sets that can be summarized in words.
This does not mean that these attributes are 'specific' to objects outside of us, but that we suppose to know them from their active effect upon us (perception).
They are therefore external attributes of *operation*, not internal 'properties'.

I assume that there is an independent world outside of me.
There are differences in quality that do not require human distinction.
They also exist without observers who have learned some discernment.
That does not have to be supposed in that outside world.

We express the partially repeating impressions that we continually receive from the outside world in formulations. If they match the wording of others (in whom we suspect a similar childhood experience and school), then they will get a probability value that can be tested by anyone else. This test is required by research.

This is only possible if verbs (actions) occur in that formulation that can be 'actually' carried out. If such an action repeatedly yields the same result, then we take the formulation as 'true'. That presumption of truth therefore only relates to the formulation. *Actual* 'reality' concerns an outside world in which we can bring about changes through *action*.

Our conclusion then may be that the formulation is 'actually true'. This formulation, however, takes at least 7 barriers between observation and proven application (truth).

A FORMULATION MUST OVERCOME 7 BARRIERS

1 **selective observation**
In the first place, our perception is a small selection of what actually 'plays'.
It is no more than a sample from a set that you should consider as very large.
This selection is influenced by what we can see, want to see or are used to see.

2 **selective representation**
Our re-present-ation (bringing back to present) of the observations is again a small selection, a further reduction of that sample.

3 **stenciling**
These selections are fitted into old generalizations, previously designed, updated and culturally restricted, templates that seem to fit.[a]

4 **verbal tolerance**
The words with which these templates are expressed as standards for exchange never fit exactly. They include different images and are often too general.
They must then be restricted and adapted with adjectives, conjunctions and adverbs.
These are, however, also generalizations. Even a restricted result generalizes.[b]

5 **word choice**
As soon as the observations are described in words, two more barriers loom.
The speaker must use the correct words (culturally agreed in previous communication) and

6 **interpretation**
these words should evoke similar images and associations.

7 **covering**
The proof that 'the message has come over' can be done by action (a laboratory test, replaying a crime, following a cooking recipe) or by a fitting reaction.
The verbal reaction 'you are right' supposes the equality of *two* images (yours and mine). That proof is never conclusive.
The reactive repetition of a reported action can be a coincidence.
How often you repeat, it remains 'inductive' (p107).

Point 7 supposes that the message is a sentence.
It must contain a verb, even if it concerns a description of a static situation without

a Even before they are recorded in nouns and verbs, there are templates for actions (for example, picking, throwing, catching) in our memory, using neural action schemes. This results in templates for more static objects (eg stones, plants, animals). With growing distinction, they are replaced by 'smaller', less generalizing sub-templates or concepts.

b Sequential words limit each other's scope until the restriction is reached in a sentence that adequately describes an action. The language of plants, animals and people first of all has to coordinate actions. It concerns actions and reactions such as between predator and prey, partners in reproduction, production and consumption. With people this can be a co-action: forming an image. The fact that communication results in a coordinated action, however, does not prove that communication contains a formulation that covers the action.

real (actual) action ('That house *is* on the other side'). The verb is usually a conjugation of 'being' or 'having'. That non-action is nevertheless represented as a verb, an action-object ('I *am* the mother, you *are* the father').

Usually an 'unblocking stimulus' is enough to trigger a clear and often complicated action schedule in any addressed organism.[a]
That is not different for people, but an action program for scientific research, for example, is not always ready in the person addressed.
It requires formulations that describe the required actions more precisely.
In addition, the aforementioned barriers should be eliminated.

The sensory barrier (1) is partly eliminated by devices that can enlarge the image with resolutions, wavelengths and observation locations not provided by our senses.

The representation that is constructed from it (2), leaves aside on the one hand many circumstances that do not seem important in advance (context), on the other hand limits the focus on objects that you can also limit differently.

The suppositions with which both selections are made (3) limit the possibility of a drastically different object selection and limitation. The plasticity and elasticity of available templates recurs with increasing discernment, because in an increasingly filled overall picture their boundaries touch and overlap. Each limit change then has an effect on other object boundaries and reduces the willingness to change the borders.

Such comprehensive changes ('reframing') are design moments in the scientific development that I want to look for in chapters 7 to 10. I have described in detail only a few examples of the development of our mathematical, abiotic, biotic and cultural assumptions, but these cross-border moments are an inspiration for designers. Furthermore, these are assumptions that can shift the view of possibilities.

The formulation of our representation (4) limits the view on possibilities for which there are no collective templates and words available. That is also a motive for designers to make drawings. These are not illustrations for a story, but images wherin different stories can be told. It is then not easy for a (often dyslexic) designer to choose the right words for the explanation of a design.

Just as wrongly chosen (5) or interpreted (6) words, drawings and sketches can also mislead (7). The listener or viewer may have other references and associations than the speaker or designer. Their templates can be differently limited.
The plasticity is in principle greater for designers. A border shift can hardly be explained otherwise than in metaphors. The design is completed in a dimensionally fixed specification drawing that allows an operator to coordinate actions.

a Tinbergen(1965)Social Behaviour In Animals(London)Methuen

4 A VERBAL LANGUAGE IS LINEAR

LOGIC AND MATHEMATICS SUPPOSE VERBAL LANGUAGE

Logic corrects verbal language

A verbal formulation that sufficiently covers an action requires a stability of well-defines variables, and a unambiguity in which formal logic provides.
Because they play an important role in chapters 7 to 10, I will first pay some attention to them. In chapter 6 I have given my overview of the current truth logic and its limited value for finding new possibilities.

Mathematics reduces qualities to quantities

Probability calculation reduces the most explicit differences of quality into quantitative deviations (§ 26 p124).
However, the set in question is defined with one or a few 'properties' in which its elements are equal, but how many properties are left out of the picture?
Each real set is heterogeneous in detail.

The repetition oriented mathematics (chapter 7) also *produces* diversity (§ 28 p150).
Minimal differences in the beginning of iterations can infinitely vary the end result.
The resulting forms sometimes remind of nature (spirals, springs), but they do not fully cover its diversity.

Analytical geometry extends the linearity of verbal language

Mathematical language supposes strictly linear sequences of variables and operations in principle, but coordinates enable to describe objects in different directions.
Variables in different directions then get different names (for example x, y, z).

These names cannot be explained by a one dimensional verbal language itself.
This ex-planation requires drawings. Trigonometric operators on angles (for example sin, tan) enable to relate different directions again in a linear sequence (§ 25 p125).
The data, however, require expression in more dimensions (tables, matrices, tensors).

§ 12 ABSTRACTIONS ARE STACKED IN CONDITIONAL LEVELS

A set is a third object

Chapter 3 often referred to abstraction, detachement from impressions and recording them in an image that can then be manipulated independently from the outside world and its spatial and temporal limitations. This is a real *action*, performed as a follow-up to, and separated from impressions, a '*co-action*' (see note p18).

The distinction between a physical context and object in a mobile appearance (object constancy) is already an abstraction. In the case of more similar appearances the object that you keep in mind is a set, a third object that covers at least two memories. That set is added to atleast two objects in order to take both together (con-cept).

If two of these sets are similar, then again you can make a new set as a third object. This creates a *stack of abstractions*.
These are the suppositions of 'well-grounded' adults who have reached the 'years of discernment' with a growing sense of distinction and imagination.

Below I review the stacking of necessarily prior abstractions, summarizing § 9. They release the first primitive representations from a series of impressions.

Difference of 'direction' supposes a first abstractive co-action

Looking in a different direction gives a different impression. Moving forward is not even necessary. You can gain that wonderful experience only by turning your eyes or your head. It changes the world as if you can conjure. If you turn your head, you also feel motor impressions and you may notice a change in sound or smell impressions.

You do not need an understanding of 'direction', but if you do not yet have words for it, then we, mature outsiders, call your primitive total experience (movement and its impressions): 'change of view direction', or (without a distinction of impressions): 'difference of direction'. After all, any change is also a difference (from 'now').

If you are short-sighted and color-blind in the beginning and you do not distinguish much details, then perhaps not much will change, but you see, feel, hear or smell a 'difference' in more directions.
You can make that difference yourself by movement. You do not have to distinguish between image, feeling, smell or sound in order to experience a *difference* as such.

In the beginning it cannot be more than 'difference' in general, but it always differs each time you move and through repetition you turn that around as well: you move to *make* a difference. If that is the case, then something has become detached from the impression itself: a different image as a goal for action.

This may play a role in making a connection between your totally different impressions from different senses (synaesthesia).

This requires some primitive representation as a binding agent.
According to Piaget, it is only the 'prefiguration' of a 'senso-motor scheme'.[a]

'Object' ⇓ a second abstraction
Object constancy is also loosening, separating (co-agitare, see note p18) a representation from impressions by movement (parallax). Those impressions must come from a different direction. So far, animals probably can do that too, but it is difficult to take *different* objects in one representation at a time.

More objects in one representation distinguishes us from animals, especially the number of action objects (later named as verbs). You do not have to suppose more than three objects, to concern tools, language and order of action as typically human.

'Sequence' ⇓ a third abstraction
Sequence (whatever the order) ⇓ a representation, detached from at least two movement impressions. If you always pass the same objects, you can keep their order. It supposes that you have remembered any difference between those objects, and with that they can become milestones to which the degree of accessibility of the focus object can be associated ('I'm almost there'), until the object is tangible as well.

'Size' ⇓ a fourth abstraction
The difference between the objects probably concerns first the extent to which they fill your field of vision, but because this varies with advancement, the experience of their manageability must be added for a sense of size.
It is a reminder of the effort ('fatigue') of grasping, lifting and appropriating, but not of the moving forward until reaching.

'Distance' ⇓ a fifth abstraction
The size of voids between objects, however, requires a reminder of the locomotion effort to pass objects laterally or to reach them head-on, an experience of increasing that void, reducing it (until colliding) or filling it with objects of different size and form (jigsaw puzzle). You keep a primitive representation of different distances, the different degree to which objects are (un)accessible to you.

'Place' ⇓ a sixth abstraction
Reaching an object by your own movement makes that object tangible, but the previous object has lost that possibility.
Again an effort is needed to make the next object tangible. The return to the first object must bring about a recognition of previously occupied places after a few rounds. Looking back they each offer a different view on the passed objects.

Receiving an inviting gesture from your father, you may leave your mother and vice versa ("Who comes in my house?"). The field of vision turns around, and that

a Piaget(1966)

difference separates itself from both impressions as 'difference of place', although that has no name yet.

A permanent place for every activity (eating, sleeping, playing) associates each field of vision from which the rest is seen with more different sensory impressions ('atmosphere', the predecessor of a set). This gives each place a different representation that can serve as a motive or goal of action.

'Quality' ⇓ a seventh abstraction

Objects can only differ if they occupy a different place, otherwise they would be one and the same object. From the child seat at the dining table, the play corner, the kitchen and the garden are objects with a different *content* in different perspectives. From a distance, places with a group of objects become one object.

When approaching, that object falls into separate objects, each with its own place, its own collection of sensory impressions and possibilities for action. So, quality differences appear at every distance (at each level of scale). Just as a place in the case of approach falls into smaller objects, their quality itself falls into different 'attributes'.

A doll can be small, blue or soft. In addition to these characteristics, a bear also has a different *form*. A tower composed of building blocks can be large, strong or hard. It falls apart in smaller objects if you overturn it.[a] In addition to these differences in content and shape, various objects also do have a difference in *structure*.

You can put a doll in your block building and let it walk.
This shows differences in *function*. When you have finished eating, you look forward to your play corner. You can play with your dolls there, build a tower with blocks or draw. The objects that you have available there can evoke different *intentions*.

Intention, function, structure, form and content are adult terms for characteristics of objects that suppose each other in this order. The *abstraction* of these different characteristics to categories is of course far from present in toddlers, but they are all already *used* to distinguish objects from each other according to quality.[b]
Insight can arise from repeated use. The knowing follows its ability.

When you move objects, the place no longer forms a hold for their recognition from a familiar atmosphere of a place.[c]
They are then only recognizable from specific 'differences of nature'. They have thus gained their own 'place' in the memory, separated from the impressions.

a Children about 3 years old may like to tease you overturning the tower you have built for them. They can take away something that you have created with effort: structure. It is an age in which, according to some researchers, contradictory needs for autonomy and esteem produce counter-conflict. It is, however also a useful experience to understand structure as it disappears.

b The frequent 'why?' questions from the fourth year onwards reveal, according to Piaget (1966), that in that 'pre-causal period' the intention is paramount. The structural-functional 'cause' of events escapes the child, because their own will is a model for what happens. Thus they may attribute everything a will, a purpose-cause that they know from their own actions (compare animism in cultural anthropology).

c My father told me to remember that he, as a child at a meeting with people who were all dressed in black, saw a 'sweet' lady who took him on his arm. It took him some time to recognize her as his mother.

4 A VERBAL LANGUAGE IS LINEAR

'NUMBER' ⇓ DIFFERENCE OF QUALITY, PLACE, DISTANCE AND SO ON

The human capacity to oversee a larger series of objects than animals ⇓ the abstraction of one representation that contains more objects at the same time. This set, as one generalized object, can in turn be represented with other sets in one representation.

If different sets (in that composite representation) contain similar sub-objects that are not distinguished by direction, sequence, distribution, size, distance or place, they can stil differ only in 'number'.
This last remaining 'number attribute' can again be released from these sets and manipulated. Arithmetic then ⇓ a further accumulation of such abstractions.

In the case of a series of separate objects, similar *partial* characteristics (for example energy content) can be released therefrom, and quantified on the basis of just this similarity.
Science ⇓ further distinguishing such characteristics, their quantification (if possible) and then the manipulation of those quantities until they prove themselves as repetition. Repetition enables prognoses in the outside world: again a further accumulation of abstractions.

The verbal language is confronted with overlapping sets, in which formal logic has to put things in order. This logic is not 'a priori' innate or a characteristic of reality, but a correction of everyday language (not an a priori as well). It must be learned from practical experience with sets as a correction of ambiguities in the verbal language.

§ 13 DESIGN ADDS AND SUBTRACTS QUALITIES

'Quality' ⇓ an *effect* of objects on their observer.
This effect can vary according to 'content', 'shape', 'structure', 'function' or 'intention' ('object layers' in ***Fig. 7*** p24). These are qualities of increasing abstraction, distinguished by these words only later in the development of our imagination, but they are already *used* earlier as characteristics for distinguishing differences in quality.

CONTENT

'Content' consists of what can be directly sensually distinguished, such as size, color, touch, smell, taste or sound.
It is the impression of 'material', a substance that can take a 'form'.

Size is already a first impression that introduces a concept for difference of quality.
It is a *quality* that does not yet have to be related to countable *quantity*. A mother (the 'big and warm' of note a p58) is something else than a manageable doll (small and cold). For that distinction, therefore, no quantitative concept is yet required.

The size, however, does not only concern the objects, but also the *frame*, the field of vision and the boundary within which objects occupy their place, and the smallest *grain* with which different details can be distinguished.
The size of the frame varies from your toy until (much later) the 'place' where you live. With your age the frame that limits you concept of 'place' grows (***Fig. 16*** p63).

Color is a powerful, but sometimes confusing 'content' tool for distinguishing objects. If the objects themselves are multicolored, with many nuances and contrasts, then the distinction between the objects is difficult.
If the environment is also multi-colored, you can speak of camouflage, so that only movement (parallax) or stereoscopic viewing gives a definite distinction.[a]

The touch impression is an amazingly distinguishing feature for differences in quality.
I saw a one-year-old boy drying his hands with a towel in the kitchen.
Then he walked to a curtain of much thinner textiles, and with his dry hands stroked on both sides for a long time and apparently fascinated by the fabric and then walked back to the towel. On another occasion, he threw himself at me, and once again touched my short shaven beard obsessively long with his cheek.
This was apparently not a sign of affection, but of an inquiring mind.

Smell or taste play an important role in distinguishing differences in quality.
They seem to intervene deeply in the memory and are associated with the other impressions as 'defining the atmosphere'.
An 'atmosphere' is remembered as a summed impression of a place, object or person where more senses and representations are involved.

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a Illustrations in children's books often use different colors for different objects, in clear contrast with the background. The impression of colors is also not unambiguous, because they are influenced by their environment and lighting.

The smell or taste impression, however, is difficult to share with others, other than by calling and combining an odor or taste image of other objects (see a wine catalog). In many animals it is an important, or even crucial, distinguishing agent (dogs, pheromones). Perhaps that is why it takes such an important place in our memory.

Sound is, just like smell or taste, 'mood-determining' and associative (birds-nature, cars-city and so on). Sound, on the other hand, is not durable but temporary, and varies in tone. What we apparently remember well is the *sequence* of sounds (music) and recurring patterns. Due to the mass media and devices, the location and object connection has been reduced. As a result, sound now probably contributes less to the distinction of places and objects.

FORM ⇓ CONTENT

I define 'form' as a spatial *distribution* of some content (such as color or material). Its *impression* (the projection on the retina or the pressure on the skin), its *expression* and its intermediate *representation* also suppose such a distribution.

This form concept covers both the *shape* of a single-colored (or with its possible nuances contiguously colored) object with a clear *contour*, and a diffuse distribution (such as a constellation of stars or a city full of buildings in a empty space).

Form is a crucial means for distinction.
The recognition of characters is based on form, still without any attached meaning. The distinction between different species of plants requires images on different levels of scale (see floras). The verbal language does not go beyond 'elongated', 'round', 'cone-shaped' or other indications that must evoke an appropriate pictural reference.

Touch and shape impressions precede the naming of color or substance (content). A form is only possible, if some content can take that form, but the form itself can be *abstracted* from that content, constructing what is left over disregarding the content.

From repeated impressions, a reduced representation (mainly the contour) is released. Then, it can be manipulated (as a variable), adjusted with new impressions, supplemented with previously unnoticed details and even filled with a different content.

The *expression* of shape can first be limited to the contour and then provided with coloring or content. Children's drawings of a head are first round, then oval and only later get ears. The form presentation thus behaves as a spreading condition of which the components can be moved until they resemble sufficiently.

When you talk *about* a form, not an impression, but a representation of that form is discussed. The impression itself cannot be fully expressed in verbal language. You never know for sure which image it will evoke within another person.

A *representation* refers to different impressions. It evokes different memories in different people. That can be surprising and useful, because a dialogue can supplement the image of the participants with unnoticed details. It can radically change, stimulate

or develop their imagination. *Reading* forces you to *make* imaginations.
A film adaptation of a book confronts you with differently elaborated images.

A photo is not equal to what you have left out of different impressions as 'shape'.
Everyone selects her or his own abstractions from that picture.
A picture, however, has more directions than a verbal report.
Viewing a picture allows more routes for description.
Each route through that image can be discussed one-dimensionally, but no matter how many stories you devote to it, they cannot fully cover the image.

They are at most a network that is stretched over the image.
There always remain holes. The drawback of an image is, that it allows more interpretations through all those possible routes.
That, however, can also be an advantage. An image that allows only one interpretation is not 'Art' challenging our imagination. That is why we appreciate Art.
If the challenge remains predictable, you may speak of 'kitsch'.

You can give separated concepts a different *place* in a form, a 'scheme'.
Such a state of distribution suggests strong and weak relationships in more directions.
One concept is 'further away' from what you mean than the other concept.
You can use lines to express relationships of different quality as a 2D pattern.
It cannot easily been 'laid out' (ex-plained) or adapted in a one-dimensional report.

If such relationships can be named as separations or connections, then I call their composition 'structure'. Without physical separations or connections that limit or guide movement, it is merely 'composition'.

STRUCTURE ⇓ FORM

On page 28 structure is defined as a set of separations and connections.
Separations prevent movements in certain directions. Where movement is allowed, you can speak of connection (the zero value of separation).

For example, you cannot walk through a wall, but you can walk alongside it (a perpendicular paradox, ***Fig. 5*** p17). The experience with separations and connections therefore includes movements and their limitations.
The separations and connections are dispersed in space. So, structure supposes form.

Structure plays a role already in the sensory-motor phase of children, because the possibility of moving, approaching, fleeing or clogging is limited by separations in (the structure of) the environment.

A box has the affective value of *security*, but at least one direction should be sacrificed for *freedom* (eg a nest). A play corner has 3 degrees of freedom, a wall 4, giving only back coverage. In all cases the environment is 'directed'.
It ables a child distinguishing directions and balancing between security and freedom.

Reduced *models* (such as a doll's house or own constructions made with toy blocks) are effective in order to detach a representation of elementary structural components (the selectors of ***Fig. 10*** p28, possibly composed in a construction) from impressions. Such imitations make the environment *within* which you can move, to an object that can be viewed from the *outside*. That is not an easy abstraction.

Structure as a means of distinguishing differences in quality ⇓ a distinction between places, sizes, sequences, objects and directions (§ 10 p58).

FUNCTION ⇓ STRUCTURE

A function of something supposes its 'operation' on something else.
Operation ⇓ movement and a selective limitation thereof. Within a structure, each selector has an internal outward function for that structure (eg producer or consumer), and the structure may have an inward function for its components (eg government). The structure as a whole may have itself an external function in a larger structure.
A function (inward or outward) therefore ⇓ always a structure (internal or external).

INTENTION ⇓ FUNCTION

If people distinguish themselves from animals, because they can imagine a greater sequence of actions (of which only the first is directly feasible and only the last accomplishes an intended state), then the first action setting a goal is that end state.

From this, the desired functions, structure, form and content are derived in the reverse time sequence of realization (plan).
In order to build a house, after designing you collect stones (*content*), locate them in a *form* that makes the separations and connections (*structure*) possible, in order to provide the *functions* you have meant according to your *intention*.

People's actions, however, are not always so conscious and unequivocally focused. Goals also originate from some more vague 'motive'.
People are put 'in motion' (motivated) by needs, eg by hunger, the need for security, affection, esteem, or to realize a satisfying self-image. According to Maslow's motivation theory[a], every need ⇓ some fulfillment of prior ('prepotent') needs.

For example, the need for safety only plays a role once the greatest appetite has been satisfied. Hunger ⇓ a body function and safety ⇓ functions that can prevent threats to that body function, and so on. I cannot therefore imagine an intention without (desired) functions, but functions without intention I can. Then intention ⇓ function.

a Maslow(1943)A Theory of Human Motivation(Psychological Review)50 p370-396

§ 14 LANGUAGE SUPPOSES A DESIGN

Fig. 7 p24 distinguishes modalities, levels of scale, context~ and object layers of design. Language then exhibits the following design features.

Modality ⇓ ((true⇒probable⇒possible⇒imaginable**)∧desirable)**
Expressions in verbal language primarily (often tacitly) suppose thruth.
The other modalities should be explicitly introduced by 'probably', or modal verbs such as 'can', 'must' or 'want'. For imaginability you may think of introductions such as 'imagine that…', 'if' or 'suppose that …'.

'Imagine that…', however, is in principle a command in the modality of the desirable. 'If' followed by 'then' refers to truth-based logic, and 'suppose that' to a possibility. You may assume that imaginability is a tacit supposition in any verbal expression, but the same words evoke different images in different people.

In education, therefore, you should often repeat the message 'in other words', and check if it evokes the image you intended, or even no image at all.

Levels of scale ⇓ (…,10m,3m,1m,…)
Words generalize similar instances, but using words such as 'function' (p20) hide an intended level of scale not necessarily shared bij the receiver of the message.
This can lead to misunderstandings if the scale is not clear from the context or otherwise stated explicitly.

Words, sentences and messages suppose different levels of scale.
They deserve different linguistic approaches.

Context layers ⇓ (Abiotics ⇑ Biotics ⇑ Technique ⇑ Economy ⇑ Culture ⇑ Governance)
The abiotic external condition for the design of a language is sound, light, or any other kind of radiation able to transfer a message. The biotic condition is the existence of an organism with appropriate senses, organs for expression, and neural abilities**.**

The proper neural ability to handle a language is more than directing and expressing a 'flight or fight' response in animals. It requires a third (interfunctional) element in one image in order to coordinate different actions with more individuals. That **technique**, as far as it is not a biotic mechanism, enables and motivates the use of a language.

You may assume that animals are able to express threatening or luring messages intended as 'Go away!' or 'Come here!', but not 'I go away' or 'He comes here'.
The crucial third element (p31) humans can combine in one image (subject, verb, result) enables full sentences with a differentiated meaning.

This technique enables an **economy** with negotiations and deals that increase the chances of survival. That enables a culture with innovations and extending knowledge of techniques (techno*logy*). Culture then enables **governance**. Culture may motivate design, using its results, but the designing itself is a preceding technique, a skill.

Object layers ⇓ (Content ⇑ Form ⇑ Structure ⇑ Function ⇑ Intention)
The object of the design called 'language' supposes a **content**: (pro)nouns, verbs, conjunctions and parts of speech specifying them. Their **form** is the conjugation of nouns (distributing in space) and verbs (distributing in time). Their **structure** is the grammar, giving each word an internal **function** in the sentence, giving that sentence as a whole the external function of communication. Its **intention** is cooperation.

LANGUAGE CAN BE CONSTITUTED

Is language constitutable according to ***Fig. 13*** on p37? It reads:

A	difference	⇑ change	⇑ coherence	⇑ selection	⇑ combination	⇑
B	metabolism	⇑ regulation	⇑ organization	⇑ specialization	⇑ reproduction	⇑
C	information	⇑ security	⇑ affection	⇑ identity	⇑ influence	

In early childhood, the use of language ⇓ that you can distinguish differences of quality (words), combined with different sounds or signs made by older people. You only have to imitate them for the time being, and hold on to that association.

(Pro)nouns determine a **difference**, verbs a **change**, **coherent** with its result in one image, and coherent with differences, changes and results once observed (meaning). Different images expand a vocabulary, enabling a personal **selection** to be **combined**.

Making different combinations may be called **metabolism** (thinking, co-acting). Changing that metabolism enables **regulation** by feed back (learning), enabling an **organization** of (co)actions (ideas). That supposes coherence in regulation. Selection of organizations enables to choose one of them, a kind of **specialization**.

You then may **reproduce** that 'plan' in reality (realization) or tell it to someone, expressing **information**. That supposes a metabolism of reproduction (language). Sharing information may enable **security** (including insecurity as a zero value).

A**ffection** supposes organized security, a personal balance between recognition and surprise (***Fig. 12*** p31), enabling **identity**, supposed in **influence**. Speaking or using language in general (supposing reproduction), enables influence on someone else. The stronger the supposed identity (authority), the greater will be that influence.

5. SCIENCE SUPPOSES A PHILOSOPHIC DESIGN

§ 15 THALES CONDITIONED DISTINCTION, REDUCTION AND GENERALISATION

As far as we know, Western philosophy was born around 600 BC in Miletus, a Greek colony with more than 80 own colonies.
There, caravan goods were shipped from the east and distributed to the west.

Fig. 17 Greek colonies[a]

Fig. 18 Meandermouth silted[b]

Fig. 19 Milete now[c]

Fig. 20 Excavations[d]

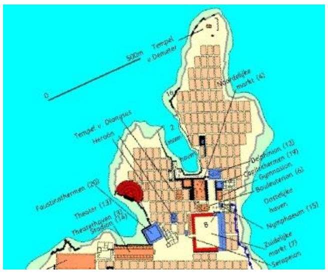

Fig. 21 Milete -450(as rebuilt a century or two after Thales)[e]

Trade with other cultures puts your own traditions in perspective. Gods appear to be local. You may *believe* that they make stars and planets move, but for navigation at sea to *know how* they move is more useful. 'True' is what works for pragmatists.

The Greek mainland, its more than 600 islands and 160 colonies were separated by water, but connected by the Greek language. The Olympics made the mutual competition into a community game *playing* the enemy instead of practicing enmity.

Because of the simplicity of the Greek language and its alphabet, many Greeks were able to read and write. So, that art was not (as elsewhere) the monopoly of priests who, based on inaccessible holy writings, could guard the true religion centrally.

No island or city-state therefore had sole rights to one surviving truth, although the mother city Athens still had some orthodox pretensions towards its children.
Greek Gods operated locally, although they met at the Olympus.
They could even deceive each other, and argue.

a Times History Atlas of the World
b https://en.wikipedia.org/wiki/Miletus
c Google Earth
d https://www.ruhr-uni-bochum.de/milet/in/topo.htm
e https://www.stilus.nl/oudheid/wdo/GEO/M/MILETE.html and Pergamom Museum Berlijn

Greek was also the first language with a definite article ('the').[a]
Greeks could therefore discuss verbs and adjectives as independent objects such as "the being" and "the bravery", sometimes even personalizing them as a goddess such as "Virtue" (Aretè) or "Wisdom" (Athena).

For scientific abstraction, it is a great advantage if you can easily make from 'fast' (ταχύσ) a quantifyable object 'velocity' (το τάχοσ) or to transform 'heavy' (βαρυσ) into the more general 'weight' (το βαροσ). Translating Greek texts into Latin (without a definite article) therefore caused difficult circumscriptions at the time.

Thales of Miletus (ca. 625-545 BC) is the first known Western philosopher.
There are no writings left of him, but there are quotes: What is difficult?: "Knowing oneself." What is easy? "Giving advice." How should you live a good and just life? "Avoid what you blame others for." (Kant's 'categorical imperative' 2500 years later).

Thales, the first of the Greek 'Seven sages' made his name by predicting the solar eclipse of 585BC. He also proved the usefulness of philosophy as a practical meteorologist and merchant by buying all the olive presses from Milete when everyone expected a poor harvest. That he foresaw the solar eclipse and the good harvest may not have been born from theoretical insight, but from an empirical alertness or even a well-documented historical series of sky conditions.

He also determined the distance to a ship from the change in angle of view during a beach walk and the height of pyramids from their shadow in relation to his own shadow (according to the 'theorem of Thales').
Those are no longer historical empirical probabilities, but mathematical proofs such as would be developed into the Euclidean geometry 300 years later.[b]

The determination of height from a shadow, however, assumes parallel solar rays, and that is not self-evident due to perspective distortion.
The sides of a road also seem to point to one point, while they are parallel.

Fig. 22 Visual deception through the perspective of sun rays [c]

a Krafft(1971)Geschichte der Naturwissenschaft I Die Begründung einer Wissenschaft von der Natur durch die Griechen(Freiburg)Rombach p49
b Henderson(2002)Greek mathematical works Thales to Euclid(Cambridge Mass)Loeb Harvard University Press
c Ton Wisselius https://www.pietsweer.nl/image/zonnestralen-41/

5 SCIENCE SUPPOSES A PHILOSOPHIC DESIGN

That the sun's rays are (practically) parallel is only apparent if your shadow on a flat surface has the same size everywhere at the same time (the same solar height). It must attest to the understanding that the sun is practically at infinite distance from the earth.

Eratostenes determined 200 years later, the circumference of the earth fairly accurate, apparently from common assumptions such as:
1 practically parallel sun rays adopted by Thales,
2 Earth assumed by Anaximandros to be a free-floating globe.

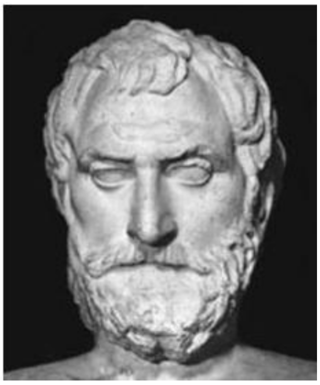

Fig. 23
Thales

Fig. 24
Anaximandros

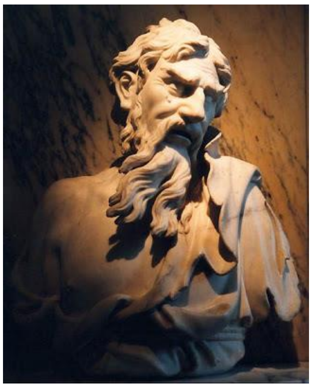

Fig. 25
Heraclites

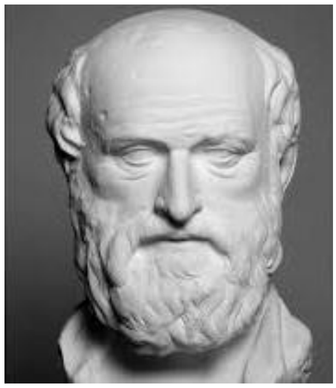

Fig. 26
Eratosthenes

If Eratostenes had assumed a flat earth, then he would have had to reject the parallelism of the sun's rays from different angles at different locations and assume a sun at a foreseeable distance.

Only the combination of both presuppositions led to the right inference from that difference. The interpretation of observations stands or falls with good or wrong assumptions. Sometimes you also have to deal with unspoken assumptions. Discovering them should be the main task of philosophy.

According to Anaximandros, a younger contemporary of Thales in Milete, the primal principle, the 'primal cause' of Being, is an indefinite 'apeiron', from which all opposites such as wet and dry would have arisen. A circle of fire would, spattered apart, revolve and new worlds would emerge and return to it. On such a floating, initially liquid, solidifying globe, organisms arose, first living in the water and only later moving to the land. That is a remarkably modern view.

Anaximandros apparently had already rejected the idea of a flat earth.
A flat earth was common because from a round earth all the water would drip down.
That in itself assumes that everything falls down parallel vertically.
Apparently that too was no longer self-evident for Anaximandros.

Herakleitos ('panta rhei', 'everything flows' as Plato summarised his thought 3 centuries later) lived shortly after Anaximandros in Efesus, no more than 50 km north of Miletus. He regarded fire and war as a primordial cause, perhaps also as a source of energy to create the opposites in the apeiron of Anaximandros.

This resembles Hegel's dialectic: every thesis evokes its antithesis to lead to a synthesis that evokes an antithesis on its turn.
In modern physics, every particle has its anti-particle. When they meet, they disappear with energy left behind. Herakleitos' fire then should make them appear the reverse.

Thales reduced the world to water as a primordial cause, because water has all known aggregation states (solid, liquid, gaseous). After the indefinite apeiron of Anaximandros, the later pre-Socrats presupposed more tangible "primal things," such as air, earth, water, and fire, precursors of Mendeleev's periodic system of elements (1869).

You can imagine a *will* of gods in the existing reality, and tell stories about their conflicting wishes as the cause of everything, but to change your attention to the question *how* they realize them and to reconstruct that *skill* is a big step to a religiously independent causality.

Ahead of Aristotle, the divine 'final cause' seems to be replaced by 'material', 'formal' and 'efficient' kinds of cause, as if a presocratic Prometheus recommends the people:

1 present materials as combinations of primal substances,
2 reduce their space to points, lines and planes (geometry), and
3 generalize repetitions to workable concepts (words and numbers).

With those representations, reductions and generalizations you can try to simulate existing or desired reality, to design it as if you were a god.
Technique is a condition for knowledge: you must be *able* to know before you can know. Thales was also known as an inventor, a designer.

Only *after* that 'designing' you can then 'empirically' check whether that design as a hypothesis corresponds to the observed reality.
You can, however, also design and realize *deviating* realities yourself.

For that you need representation tools, similar to knives, sieves, binders.
Ockham also had a 'razor' in the 14th century that resembles a statement attributed to Einstein: "Make everything as simple as possible, but not simpler than that."

§ 16 PLATO'S SOPHISTIC DEBATE CONDITIONED SCIENTIFIC DOUBT

Defending trade interests in various other cultures resulted in a culture of hearing, rebuttal and judgments based on arguments so that you could separate as friends keeping trade relationships. You could learn from 'sophists' how you can be right.

The 'fair debate' as it still appears in a promotion and court session contains useful sophistic rules:

1. one proposition at a time is being examined for its tenability;
2. regardless of your personal opinion, you agree who will defend the proposition (in the *role* of defender) and who will attack him (in the *role* of opponent),
3. the opponent challenges the defender to clarify the proposition on the basis of improbable interpretations ("Do you mean by this statement, that ...?");
4. the opponent proposes a common basis ("Do you agree that ....?");
5. if the defender accepts te common basis, then the opponent attacks by pointing out a possible contradiction between the proposition and the agreed common premise;
6. the proponent defends with an attempt to refute the assumed contradiction.

Sophists had the name to talk straight everything that is crooked, but they are the precursors of Descartes' doubt and Poppers falsifiability. According to Popper a proposition that cannot be contradicted is by definition not scientific. There is no pro and contra, no counter-learning, no control, no criticism or dialogue possible.
In this sense playing Herakleitos' war in a debate, is also the father of science.

Sophists didn't make a name with their own system, but with their method.
The famous sophist Protagoras ("man is the measure of all things") was embarrassed ('aporia') by Socrates in Plato's dialogue 'Protagoras' when he defended that 'virtue' can be taught, and that he asked money to do so.

Fig. 27
Virtue as a goddess

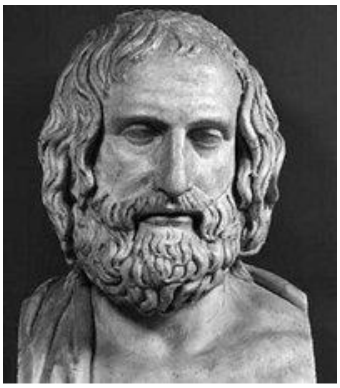

Fig. 28
Protagoras

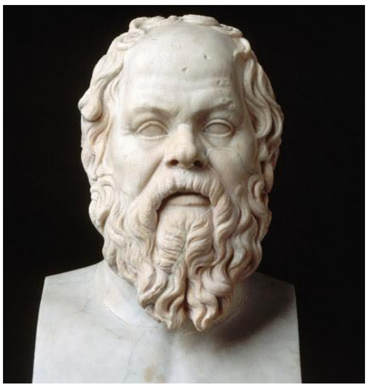

Fig. 29
Socrates

Fig. 30
Plato and Aristoteles[a]

To the amusement of youthful bystanders, Socrates also embarrassed dignitaries in the streets of Athens with his annoying questioning of what 'virtue' actually is. He did not leave own writings, but his student Plato expressed his thoughts in dialogues.

a Detail van Rafaël Santi(1510)Stanza della Segnatura(Rome)Vaticaan

As the cultural center of the Greek world, Athens remained more orthodox than its colonies, to which dissidents disappeared with their views.
Socrates was convicted in Athens on charges of blasphemy and spoiling the youth. He did not flee, but chose the poison cup.

The Greek language made it possible to independentize an adjective, the property of an object (such as 'wise' to 'wisdom', 'virtuable' to 'virtue', even personalized as a goddess). If you regard such words as real, independent objects (medieval 'realism'), then you (like Socrates) can continue to inquire about their 'essence', but every explanation ends adjectively and bound by examples.

I share Poppers reluctance against such 'essentialism'[a]. Words are just collective names that we have invented ourselves (medieval 'nominalism'). Similarly, I cannot possibly share Plato's view that our reality is only a projection of ideas ('idealism').

On the contrary, actual things project themselves in our mind, and when those impressions repeat themselves we invent words for them.
The success of Plato in the Christian world is understandable when you read in the gospel of John 1: "In the beginning was the Word."

Plato's hero Socrates was, moreover, like Jesus Christ, a martyr of his own conviction. This creates a sense of responsibility for their relatives, apparently even when it comes to pagans. Dante (1265-1321) tells in his Divina Commedia how the not baptized gentiles Socrates, Plato and Aristotle did not end up in Hell.
They had received their own place next to Heaven.

You may reject Plato's idealistic aberrations, but he has made the dialogue of the sophists a standard of literary expression, philosophy and science.

A dialogue avoids one-sidedness.
Opposing views are given their own face and power of persuasion. The similarities and differences of insight per character lead to the analysis of their overlaps or mutual exclusion that lead to logical conclusion with conjunctions such as 'and' or 'or'.
Plato's student Aristotle will analyze this logic and will make it a scientific discipline.

The convincing truths of mathematics as a world of ideas that can develop independent from reality and yet seems to project itself to that reality everywhere, was an important argument for the idealistic view. You can, however, imagine mathematics also as an empirical science or even technique of repetition, derived from our experience with everything that repeats itself in reality *and* in our representation.

Mathematics distinguishes different types of repetition, such as making equal steps (line), with equal deviation (straight or circle), with equal units counting, counting back, multiplying, integrating, and differentiating.
You can make seeming differences equal by equations. What repeats itself in the real

a Popper(1976)Autobiografie(Utrecht 1978)Spectrum Aula world can be counted and numbered. Conversely, the representation of a mathematical product can again be realized in real repeating production.

What does not repeat, the one-time or unique cannot be counted, but only told. The unique does not lend itself to generalization and therefore not to a predictive science that relies on repetition. For generalization, mathematics is the tool par excellence, a technique for simulating all types of repetition and equality. Mathematics only assumes a difference *between* the qualities that can be counted (variables), but it supposes equality of character and size *within* those variables.

§ 17 ARISTOTELES CONDITIONED EMPIRISM AND LOGIC

Unlike Plato from Athens, his student Aristotle from Stageira ('the Stagirite') no longer assumed that you, as a midwife, only have to redeem the ideas that are still sleeping in a student in order to give birth to knowledge.
Not all knowledge of the world can already be present as an idea in every student.

This was probably also apparent from the strange objects of which no one had any idea before, that Aristoteles' pupil Alexander the Great sent him for his collection during his conquest up to the Indus.
Aristotle taught to trust your own senses and to process that variety of impressions to usable knowledge using only 4 innate word categories[a] and 4 forms of judgment.

Categories:	Judgment forms:
substance,	affirmative - negative,
quality,	general - special ,
quantity,	some - one-off,
relation.	necessary - possible.

Fig. 31 Aristoteles' categories and judgement forms

With different word categories: substance, quality, quantity and relation, you can form a judgment in a sentence with subject and predicate: affirmative or negative, general or special, some or one-off, necessary or possible.

From a general judgment (major) and a special judgment (minor) you can derive a third judgment, a conclusion (deduction)[b].
A general judgement is a preliminary generalization from many examples (induction).

Deduction	Induction
Major: If I am in Delft,	Aadorp is a place in The Netherlands,
then I am in The Netherlands.	Aagtdorp is a place in The Netherlands,
	…
	…
Minor: Well, I am in Delft.	Zwolle is a place in The Netherlands.
Conclusion: I am in The Netherlands.	So: All places are in The Netherlands.

Fig. 32 Aristoteles' logics: the combination of judgements

In observable reality, however, no number of observations is sufficient for 'complete induction'. If you add 'London is a place in England' to the 4000 from Aadorp to Zwolle in The Netherlands of ***Fig. 32***, then the conclusion 'all' has already been falsified. Induction, a general judgment, therefore always deserves doubt.

In mathematics, however, 'full induction' is accepted if you could repeat the same operation infinitely. For example, you approach zero by repeated halving.
You never reach that zero, but you can accept it as the final result ('limit') of an imaginary infinitely repeated operation of halving.

a Aristoteles(-335?)Categories(Cambridge Mass1983)Loeb Harvard University Press p17 mentions 10, but the others can be traced back to these 4.
b Aristoteles(-335?)Prior analytics I(Cambridge Mass1983)Loeb Harvard University Press p199

For Plato, special cases came from more general ideas (idealism); for Aristotle, the general is the collection of special cases (empirism). Yet the platonic idea ('eidos' is literally 'visual form') comes silently back to Aristotle as the form in which a substance (material or content) takes shape. The pure, substance-free form is an ideal (geometrical) idea, and any substance has some resistance to take its intended shape.

Movement is a change of form, against which any material will resist.
Any movement must have an unmoved mover, the infinitely good and beautiful against which any substance resists. The material resistance against form is the cause of all imperfection against a final divine or human will.

Aristotle then distinguishes four types of cause[a]:

1 form cause,
the perfect mold;
2 material cause,
the resistance of matter;
3 efficient cause,
the unmoved mover, *source* of motion,
4 final cause,
a divine or human will.

Fig. 33 Aristoteles' causality

The resistance is a precursor to Newton's mass inertia. For Newton, however, not the movement of a mass itself, but its acceleration or change of direction has a cause (attraction or repulsion). Newton does not need a form cause or a final cause.
Mass resists against movement *and* attracts (gravity) or repulses (at collision).

The basic concepts of Aristotle's physics are space, time, substance, cause and movement. He assumes a goal directed efficiency.

Fysics **goal directed**	**Biology** **entelechy: soul-steered**	**Humanistics** **layered**
Space	Unmoved mover, the soul	Vegetable nourishing
Time	(active form)	
Substance		Animal feeling
Cause	Moved body	
Movement	(passive substance)	Human thinking

Fig. 34 Aristoteles' physics, biology and antropology

For his biology, the soul is the cause of form, the unmoved, focused mover. The body is the moved, but resisting substance, the tool (organon) of the soul (entelechy).
A human has a plant-nourishing, animal-feeling and human-thinking layer.

The large series of surviving works by Aristotle has the character of an encyclopaedia that covers all knowledge at the time.
That great design of Aristotelian science dominated the literate world until the end of

a Aristoteles(-335?)Metaphysics I(Cambridge Mass1996)Loeb Harvard University Press p17 the Middle Ages with an almost inviolable authority (***Fig. 35***).

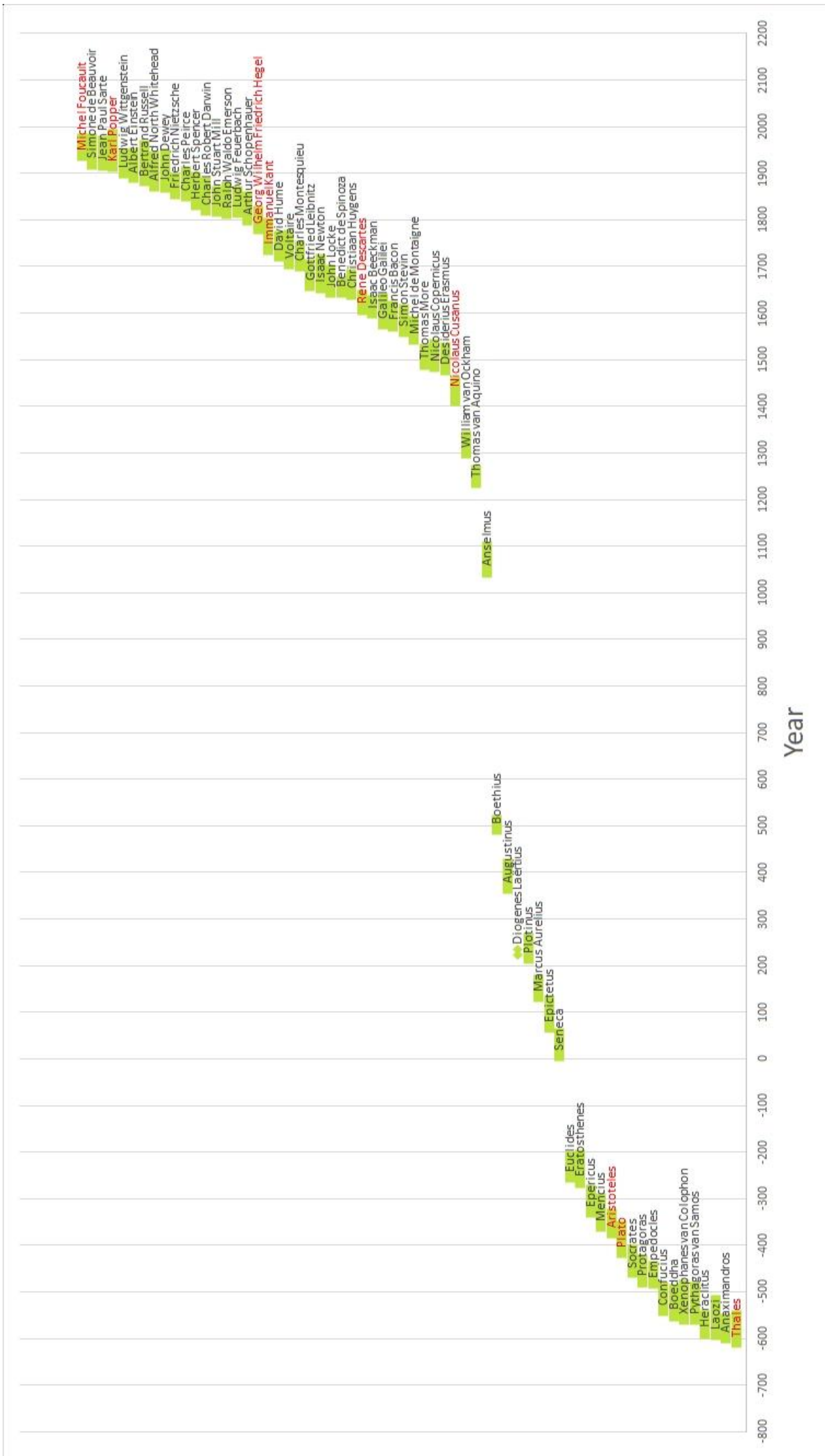

Fig. 35 Philosophy from Thales until Foucault show a gap in the Middle Ages

§ 18 CARTESIAN RATIONALITY CONDITIONED CERTAINTY BY DOUBT

Descartes is considered to be the founder of modern philosophy, but two centuries before Descartes at the end of the Middle Ages, Cusanus (1401-1464, a German lawyer, philosopher, mathematician, astronomer, humanist and cardinal) testified of far-reaching modernism and tolerance[a].

The prominent role of mathematics in his work up to his theology makes him even more rational than Descartes.[b] He considered all religions with great tolerance as parallel (not crossing) paths to the same God at an infinite distance.
So, nobody can really know Him ('docta ignorantia').

He negotiated as a Cardinal and connoisseur of Islam and Koran on behalf of the Pope with the islamitic conquerers of Constantinople, shortly before the Reformation brought about the polarised extremism that Descartes had to take into account.

This inventor of negative lenses for myopia, an advocate of accurate measurement and weighing, denied apparent mathematical counterparts such as straight and round ('coincidentia oppositorum') with mathematical arguments. He left Deventer a house for poor students and his birthplace Kues on the Moselle a still existing retirement home with the library of his own and other medieval manuscripts.
He did, however, not make school like Descartes did 200 years later.

Fig. 36
Cusanus

Fig. 37
Copernicus

Fig. 38
Descartes

Fig. 39
Newton

Descartes' paradox that you can derive certainty from doubt is an example of Russell's paradox: the set of all sets cannot contain itself[c]. Similarly, the set of all *doubts* cannot contain itself. If you look at that set from the outside, then *there* is no doubt about the *fact* that you doubt. Descartes' "Cogito ergo sum" (see note p18) is less convincing by circularity, if you realise: "I think, so *I think* I am". 'I am' is also a thought after all.

a Müller(2013)Die Modernitäten des Nikolaus von Kues(Mainz)Historische Kulturwissenschaften

b Dijksterhuis(1975)De mechanisering van het wereldbeeld(Amsterdam 1980)Meulenhoff p248 provides a clear overview of Cusanus' ideas.

c As an element of a set *with all sets*, it no longer contains all sets. This paradox is described in Russell (1903) The Principles of Mathematics (London 1996) Norton. It is remarkable that Russell (1946) History of Western Philosophy (Cothen 1990)Servire in his otherwise crystal clear chapter on Descartes on p588 of the Dutch version himself did not notice that this thinking about doubt is an example thereof.

You cannot talk *about* concepts using the same concepts. For that 'meta-language' you need other concepts. May be therefore Descartes advises to talk in symbols about numbers (variables). By doing so, he prepared the use of algebraic expressions.

Similarly, you cannot think about thinking with the same thoughts you think *about*. Understanding is a different idea than what must be understood.
Descartes thought in other (algebraic) concepts about geometry (coordinates) and thereby became the inventor of analytic geometry.

The use of variables and coordinates is Descartes' most important lasting contribution to science. He derived his prestige from the application of mathematics in his sometimes pioneering, yet immature physics, but finally, he has remained best known as the philosopher of rationalism.

Copernicus had dared to doubt about Aristotle in the previous century, and Descartes joined the growing choir of those doubters.
They dared to think for themselves instead of following the authorities without criticism, as Kant had to advise again two centuries later.

If you simply learn by heart what you learn, then you will not *understand* it, get a *grip* on it from *outside*, do something with it, contrast it, counter-learn, check whether it is true: doubt.

Descartes had learned practically everything there was to be learned from the Jesuits in Paris. Every idea, no matter how unlikely, had been worked out by some authority in the past. What can you be sure of, how should you check that? By continuing to doubt yourself (think)!

He went on a journey and found the most improbable and mutually contradictory views in other cultures. However, at the same time he had to admit that such views were shared by very sensible people, and each individual mind was able to check a mathematical proof without external authority.

Mathematics turned out to be the only area in which this individually developed certainty was finally shared by everyone as 'evident', clear and well-distinguished ('clairement et distinctement'). That is not surprising if it only involves repetition.

In the winter of 1619, Descartes, 23 years old, retired to Germany as a recluse for a few months 'in a well-heated room', asking how this mathematical evidence could also be achieved in areas other than mathematics.[a] He resolved:

1 never to accept anything for authority again if you yourself have still any reason to doubt it;
2 to divide each problem to so many parts as possible and required, to resolve it;

---

a Descartes(1637)Vertoog over de methode(Amsterdam1937)Wereldbibliotheek or the Bibliotheek Descartes deel 3 van Boom, Amsterdam. In the first three parts it turns out not to be a dry matter, but a very entertaining, modest autobiography with a wealth of wise examples. In the fourth part, however, it becomes less accessible and convincing metaphysics, in the fifth part an outdated description of biological facts as proof of the inanimate mechanics of the body and the animal as a machine, and in the sixth part the explanation why he did not dare to publish parts earlier in detail in view of the then recent conviction of Galilei.

3 starting with the simplest, but also search coherences that deviate from that natural order;
4 making summaries and general overviews everywhere so complete that you are sure not skipping anything.

In dealing with others, however, he would have to live with uncertain beliefs and customs that he did not want to condemn before he himself was completely certain of their inaccuracy. To that end, he decided to:

1 obey the customs of the country, but also from your own religion and to stay in the middle of extremes;
2 be as determined as possible (keep course) once you have decided on views, even if you still have doubts;
3 conquer yourself rather than destiny; rather change your own wishes than the world order (stoic);
4 consider in succession the activities of people in this life in order to choose the best.

He did the latter by traveling around for nine years until he decided to settle in the Netherlands, the first republic of Europe, in order "to avoid all the places where I could have acquaintances and to withdraw here in a country where ...

> because of the long duration of the war such an order has been created that it appears that the armies that are maintained there serve only to be able to enjoy the fruits of peace with greater security; and where amid the crowd of a very active people who are more concerned about their own affairs than curious about those of others, without missing the comforts found in the most visited cities,

I have been able to live as lonely and withdrawn as in the most remote deserts. "


Fig. 40 Frederik Hendrik van Oranje

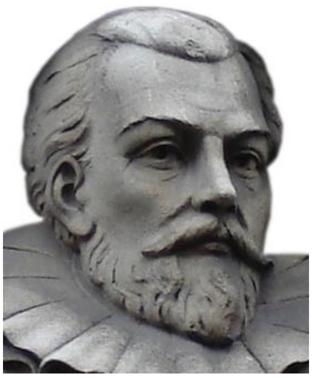
Fig. 41 Simon Stevin


Fig. 42 Baruch de Spinoza


Fig. 43 Christiaan Huygens

However, it also had been the land where the prince of Orange protected him against attacks of straight-line Protestants, where he met Simon Stevin (in several ways ahead of Galilei) and his friend Beeckman (in several ways ahead of Newton), where the microscope was invented and telescope with which Galilei discovered the moons of

Jupiter, where Spinoza grinded lenses and worked out his 'Ethics' mathematically[a], where Christiaan Huygens admired and corrected him.[b]

In the Netherlands, he designed a metaphysical world view based on two evidences:

1 Individual doubt proves that you think that you exist as a thinking being, and that you can distinguish 'whether or not' in all parts of that existence.

2 The doubt and the representation of what does not, not yet or no longer belongs to your existence, awakens the awareness of your own imperfection.
That implies a sense of a comprehensive perfection outside of you, his 'proof' of the existence of God.

How these two 'evidences' lead to his idea of a complete separation between immortal spirit and mortal body (cartesian dualism) is beyond me.
That distraction does not excel in rationality. The small, doubting, imperfect, thinking ego is in Descartes's view in contrast with the great, perfect certainty of God's spirit.

Science is the individual *pursuit* to that comprehensive certainty. If that doubt and the ensuing certainty is 'mind,' where does the 'matter' that we perceive come from?
Is that a divine conception ('creation') that moves along (co-agitates) with the divine thought as a world soul (aristotelian entelechy)?

If that bound matter has a substance other than the free spirit, how can the spirit take hold of our body? Spinoza soon rejected that dualism.
Now that we have learned machines to doubt with switches (transistors) and finally even to think, to me that debate seems over.[c]

Descartes' rules for the mind seem more important to science than his metaphysics.
From 1620 he wrote the 'Regulen van de bestieringe des Verstants' but never published them himself.
The manuscripts were left with Princess Christina after his death in Stockholm in 1650. They only appeared in 1684 after many wanderings (involving Huygens and Leibniz)[d] for the first time in Dutch and only in 1701 in Latin.

The first sentence made the biggest impression on me:

" People, as soon as they recognize any equality between two things, have the habit to suppose that equality in everything even in which those things differ."

This puts a bomb under the usual statistics on heterogeneous sets such as people in medical science and biology. You cannot apply a conclusion about one equality between objects to those objects, if they may differ in other characteristics.

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a Spinoza(1677)Ethica https://www.thelatinlibrary.com/spinoza.ethica1.html ;
Spinoza(1677)Ethics(WWW1997)MTSU Philosophy WebWorks http://frank.mtsu.edu/~rbombard/RB/Spinoza/ethica-front.html

b Dijksterhuis(1975)De mechanisering van het wereldbeeld(Amsterdam 1980)Meulenhoff

c Sjoerd Zwart taps my fingers here: "The debate about dualism is not yet closed in the philosophy of mind. Popper, for example, has advocated it with Eccles (famous neurosurgeon) in 'The self and Its Brain' (1977)."

d Descartes(1684)Regulae ad directionem ingenii Regulen van de bestieringe des verstants(Den Haag 1966)Nijhoff, or published in more intelligible Dutch in the Descartes library part 1 of Boom, Amsterdam in 2010.

Fig. 44 Leibnitz

Fig. 45 Hume

Fig. 46 Kant

Fig. 47 Darwin

Leibnitz is the first to distinguish, apart from the truth, the modality of possible worlds that is crucial for designers, but further he followed Descartes. They share the view that we can go back to the experience of untouchable or self-evident truths.

"The fundamental likeness between Leibniz and Descartes is in the conception that we can go back to experience until we come to unassailable or self-evident truths. The manner in which these truths are conceived is alike in both, although Leibniz makes the distinction between *verites eternelles (a priori)* and *verités de fait (a posteriori)*."[a]

Kant will elaborate this distinction more clearly than Descartes.

a Delisle Burns(1916)Leibniz and Descartes(The Monist Oxford University Press)October 26 4 p525-526 https://www.jstor.org/stable/27900608?seq=1#metadata_info_tab_contents

§ 19 PHILOSOPHERS FOLLOWING KANT LOST SCIENTIFIC RELEVANCE

Hume had stressed: back to the facts, first look for yourself, no a priori's, categories and assumptions in advance! Even a causal relationship is a mental assumption.
The senses only observe a *sequence* of events.
The mind reduces the infinite variety of impressions in manageable generalizations.

Kant, however, gave idealism a place back in science, with 26 a priori ideas in his still popular and highly cited science design. Next to ideas of *space* and *time* located in the senses, our mind then contains 24 ideas in its 'reason'.

	Categories	**Kinds of judgement**
1 Quantity	Unit	General
	Multiplicity	Special
	Allness	Singular
2 Quality	Reality	Affirmative
	Negation	Denying
	Constraint	Infinite
3 Relationship	of inherence and subsistence (substantia et accidens)	Categorical
	of causality and dependence (cause and effect)	Hypothetical
	of community (interaction between active and passive)	Disjunctive
4 Modality	Possibility, Impossibility	Problematic
	Existence, non-existence	Assertory
	Necessity, Coincidence	Apodictic

Fig. 48 Twenty four a priori categories and kinds of judgment according to Kant [a]

These ideas would be necessary to make 'knowledge' possible.
That 26 ideas is already less than what Plato assumed as present in everyone's mind from past lives, but it is again more than the 8 of Aristotle.

According to Kant an intellectual 'judgment' attaches a 'property' of one or another 'category' (***Fig. 48***) to an 'object'.
In order to do so, however, you need also an *ability* to judge (to choose an appropriate adjective for a given noun), apart from the senses. Moreover, an overarching 'reason' from self-chosen ideas and principles must determine what is 'appropriate'.

Kant supposes this multitude of instances to be a unity: the subject ('I', 'you', '(s)he').
The unity of an indivisible individual is a crucial assumption in any of Kant's 'proofs'.
The subject, however, can be a multitude.[b]

Identity is flexible, playing different roles in different contexts.
It can change. It develops, and must be learned in childhood, *a posteriori*, composed and stabilized in order to remain a recognizable subject in communication with others.
Identity must be chosen from a multitude of possibilities to be unique, and held fast.

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a Kant(1787)Critik der reinen Vernunft I §9, §10(Frankfurt am Main1976)Suhrkamp p111-121 or Kant(1787)Kritiek van de zuivere rede I§9, §10(Amsterdam 2004)Boom p161, 168

b Foucault will oppose that idea of unity in an individual. Minsky also assumes a multitude of individual judgmental actors within one individual in the very readable and even exciting: Minsky(1985)The Society Of Mind(NewYork 1988)Simon Schuster. Bob Dylan (2020) sings "I am a multitude".

5 SCIENCE SUPPOSES A PHILOSOPHIC DESIGN

I have elaborated that in chapter 3 p48.[a]
So, Kant's 'unity' can be missing, and is therefore not *a priori* present.

Moreover, how could you imagine after Darwin, that once an animal has suddenly become an intelligent person with coincidentally 26 mutations and the implementation of all these traits simultaneously?

Kant's kinds of judgement and word categories may be philosophically interesting and useful to be distinguished, but there are overlaps and hidden suppositions making their 'a priori' to an uncontrollable and unnessecary complex starting point.
Philosophers following Kant lost scientific relevance.

Science went its own truth-finding way with well-defined objects, operations, experiments, *reliable* observation and *valid* reasoning.

Both philosophy and science, however, lost the view on possibility-finding, *design*.
The common concept of 'valid reasoning', the common *logic*, took that view away.
Let me investigate that after § 20 in the next chapter 6.

a The experiments with children in a series of publications, summarized in Piaget (1966) La psychologie de l'enfant (Paris) Presses universitaires de France can be interpreted this way, even though Piaget himself claimed to be a Kantian.

§ 20 PHILOSOPHY SUPPOSES A DESIGN

Fig. 7 p24 distinguishes modalities, levels of scale, context~ and object layers of design. Philosophy then exhibits the following design features.

Modality ⇓ ((true⇒probable⇒possible⇒imaginable**)∧desirable)**
The modality of philosophy is primarily **truth** and ethics (supposing **desirability**). From Thales to Kant, the ethical imperative reads in short: 'Avoid what you blame others for'[a]. From this rule, many derived philosophical questions have been raised, for example about knowing yourself, understanding the rest, your moral duty and pity.

An inherited religion may imprison such truths in its own non-negotiable belief, blaming other religions. That has caused bloody wars. It hinders doubt and debate, proving the current significance of philosophy beyond science and religion.

Speaking the truth is an ethical criterion motivating science and jurisdiction. Aristoteles and Leibnitz took steps towards **possibility**, but that was no match for the omnipresent quest for truth and virtue.

Levels of scale ⇓ (…, 10m, 3m, 1m, …)
Philosophy has spoken out from atom to universe, but its main focus has been the human scale, ranging from human knowledge, the way we (should) think to human culture and politics. It seldom concerned the body and its internal biotics.

Context layers⇓(Abiotics⇑Biotics⇑Technique⇑Economy⇑**Culture⇑Governance)**
The presocratic fascination for **abiotics** and **biotics**, shifted to the emphasis on human affairs by the sophists and Plato. The context of **governance** and **culture** overshadowed the wonderment about nature. Questions and answers about (a)biotics stabilized, frozen in the writings of Aristotle, authoritative for more than 1000 years.

Some philosophers were artisans, engineers or tradesmen. So, **technique** and **economy** may have been a context of philosophy, but it has not often been its object. Diogenes Laertius (ca 250 AD)[b] summarised the lives of more than 80 antique philosophers, but he did not mention Archimedes (ca -230) or Euclides (ca -300).

After Pythagoras (ca -530 BC), mathematics apparently had been separated from philosophy as an independent discipline, at most to be *referred to* by philosopy. That would occur more often after the Renaisance, but Newton(1687)[c] still called his groundbreaking physics 'natural philosopy'.
Smith(1776)[d], however, founded economy as an independent discipline.

Object layers ⇓ (Content ⇑ Form **⇑ Structure ⇑ Function ⇑ Intention)**
The **content** of philosophy has been separated as body and soul, matter and ideas, but Spinoza (1677) united them already as one 'substance'. The **form** of philosophy as a

a But what if you do not blame crime?
b Diogenes Laertius(ca 250AD)Lives of eminent philosophers I, II(Cambridge Mass2000)Loeb Harvard University Press
c Newton(1687)Philosophiae Naturalis Principia Mathematica(London) ; Newton(1687)Principia, the mathematical principles of natural philosophy(New York1846)Adee; https://archive.org/stream/newtonspmathema00newtrich#page/n71/mode/2up
d Smith(1776)An inquiry into the nature and the wealth of nations(London)

design is linear and the **structure** on the lowest level is that of verbal language. Philosophy is seldom expressed in images, enabling more dimensional structures.

Some art and poetry may include philosophical views, but these miss the exactness, required for criticism and debate. The **function** may be described as changing suppositions, the **intention** as integral understanding (parts of) the world. Science then has the same function and intention, splitting these parts in specialized disciplines.

PHILOSOPHY CAN BE CONSTITUTED

Is philosophy constitutable according to ***Fig. 13*** on p37? It reads:

A	difference	⇑	change	⇑	coherence	⇑	selection	⇑	combination	⇑
B	metabolism	⇑	regulation	⇑	organization	⇑	specialization	⇑	reproduction	⇑
C	information	⇑	security	⇑	affection	⇑	identity	⇑	influence	

These *words* may cover all objects of philosophy, but these have been elaborated only in the modality of truth or desirability.
The modality of possibility, its imagination and its suppositions (here expressed in an assumed sequence with ⇑), would extend the context and object of philosophy.

6. LOGIC SUPPOSES A LINEAR LANGUAGE

6 LOGIC SUPPOSES A LINEAR LANGUAGE

This chapter takes some distance from logic, considered as *the* a priori basis of our rational thinking. Logic can be understood as a design, based on experiential science. After millions of years hunting and gathering we have got some experience with sets. Words name sets and logic detaches their overlaps.

You can summarize similar actions, subjects and objects of action in sets.
You can imagine something inbetween or beyond. The human ability to gather more than two objects in one image brings a summarizing, intermediate third within reach. You can imagine, represent and combine them in an intermediate language in order to coordinate actions.

Logic formalizes the art of combining sets with conjunctions, but our capacity for co-action (thinking) includes more. The one-sided fixation on logical *truth* within a linear language, limits the view on *possibilities* that are not (yet) true.
The ability to design requires more space than the logical space.

§ 21 LOGIC IS LINEAR, LANGUAGE- AND TRUTH BOUND

THE LOGICAL SPACE IS LIMITED TO VERBAL LANGUAGE

If you point to something or someone, and you say a word (eg 'administrator'), then bystanders can nod or shake 'no'. The first means 'true', the other 'not true' ('false').

Each word, referring to an actual object, has such a positive or negative 'truth value' (true or false) in the 'logical space'. The usual logic excludes a third possibility (someway true *and* false) as a 'contradiction'. It is an administrator or it is not an administrator, not both as in 'multivalent logic' (not regarded here).

Symbolic logic uses the symbol '¬' for 'not' and '∧' for 'and'.
Words ('variables') or assertions ('propositions') are abbreviated to characters (eg 'a' for 'administrator'). So, a∧¬a ('a and not a') is an inadmissible contradiction.

This logical prohibition shows the *linear* limitation of a verbal language such as logic. A perpendicular view on a straight *line* 'b', may show a *point*, so b∧¬b.
A 2D perpendicular symbol ('⊥') could make that contradiction allowable: b∧⊥¬b.

If you pronounce a second word (for example 'charming') before 'administrator', then that combination (charming administrator) becomes a 'judgment'.

The bystanders can agree in one way and not agree in three ways. The logical space then consists of four 'cases': A administrator and charming, B administrator and not charming, C not administrator and charming, D not administrator and not charming. With every new qualification ('predicate') that number of cases doubles.

In the upper left corner of ***Fig. 49***, the logical space of 'a' (for example 'administrator') and 'c' (for example 'charming') is displayed and subdivided to 'a', '¬a', and 'c', '¬c'.

They can be true (white) or false, not true (gray). The expressions $a=f_1(x)$ and $c=f_2(x)$ below mean that the words a and c here are a different name, attribute, or 'operation' f of the *same* object x (the object x that you have designated).[a]

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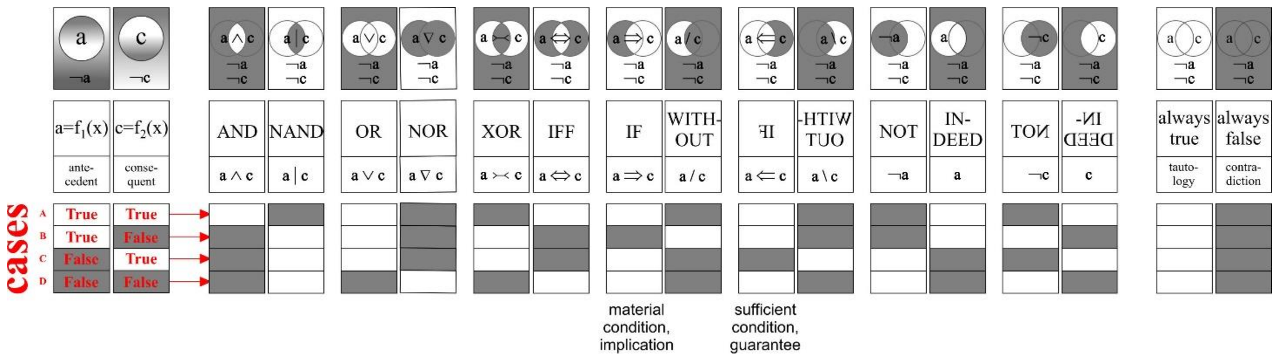

Fig. 49 Truth table

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a Ryle(1949)The concept of mind(Chicago)University Press in his introduction calls it a violation of logical rules if you relate different 'logical types' in an assertion. However, he does not provide rules for that 'category discipline'. Here, I choose one object with different characteristics as an example, so that by definition I keep the same category or type for the object. However, the problem remains with its added attributes ('predicates'). You cannot say that something is 'redder than round' (see further p118).

As soon as a and c are linked with conjunctions, their sequence as antecedent (a) and consequent (c) is important. Below, I will further specify the options A, B, C and D that may be 'the case'. Peirce (1883) was the first to design a table of truth values for conjunctions, but Wittgenstein (1918) made it popular.[a]
Wittgenstein began with the famous phrase: "The world is all that is the case."
The logical space then contains all *possible* cases, even if they are not 'the case'.

If you now put a conjunction between a and c, that *combination* will have its own 'truth value', shown in the top row of ***Fig. 49*** as white (true) and gray (not true) subsets with every combination in their logical space. In the bottom rows they are specified for each case A-D from both a and c true until both false.
That creates some surprises.

For example, if a and c are both *false* (case D), a combination such as 'a∇c' ('neither a nor c') still can be *true*. This applies to more conjunctions (the white cells in the bottom row), for example 'if a then c' ('a⇒c').

Fig. 49 thus combines a and c in each of those four cases A, B, C and D with the conjunctions coded in the middle row:
'a and c', 'not a and c', 'a or c', 'a neither c', 'either a, or c', 'a then and only if c', 'if a then c', 'then a if c' and so on.

In each case there are 16 combinations: 8 conjunctions and their denial. For example, 'a⇒c' ('if a, then c', 'a implies c') means the same as ¬a/c ('not a without c').
The negation of ⇒ is in the next column symbolized as /.
Without c, a is not true, but *everything else* is true! That is 'counter-intuitive'. This 'implication' limits a to a certain part of c ('a as far as c') and denies only 'a if not c'.

By contrast, the complete denial "not a" ("¬a") refers to an indefinite remainder (everything except a). 'Not' therefore shows an awareness that there are other possibilities. Designers need such awareness without limits.

PREDICATE LOGIC CORRECTS THE FALSE USE OF CONJUNCTIONS
Charming administrators are administrators *and* they are charming.
The overlapping of the set of all administrators with the set of all that is charming is delineated by the conjunction 'and' ('∧') from the rest (no gruff administrators or charming movie stars).

In common language the word 'and' is also used for both sets together (everything that is administrator and charming). A better conjunction is then 'or' ('∨'), if that at least does not have the meaning of exclusive *ór* ('either ... or' '>–<'): 'Do you want jam *ór* cheese on your bread?' (not both). The symbols distinguish them better than words.

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a Peirce editor(1883)Studies in Logic by the Members of the Johns Hopkins University(Boston)Little, Brown & Co
Wittgenstein(1918)Tractatus logico-philosophicus Logisch-philosophische Abhandlung(Frankfurt am Main 1963)Suhrkamp.
Except both, Dodgon in 1894 (the writer of Alice in Wonderland), Shosky, and Russell in 1912 are also called as inventors.

Thus, conjunctions are not always used unequivocally, especially when a sentence has more conjunctions. For example: 'Do you want cheese and jam on your bread or cheese and hail and water or milk and if milk then cold or warm?'. With symbols, phrases with a large number of conjunctions can be handled correctly ('valid'). That is particularly useful for algorithms with many operations.

If you assign properties ('predicates') to an object with a conjunction ('judgment'), then a contradiction can occur with an imprudent use of conjunctions. Sentence 1: "Administrators are charming and not charming" is such a contradiction, but it may be intended as sentence 2: "There are charming and there are not charming administrators".

In order to avoid the contradiction of sentence 1, the word 'and' could be replaced by an exclusive '*ór*' (>–<). That, however, changes the meaning to an assertion that is not precisely meant in sentence 2. Sentence 1 contains a hidden generalizing supposition: 'For all administrators applies: ...'.

Sentence 2 does explicitly *not* generalize by the phrase 'There are…'. That makes it a safe statement. In logic, this distinction is provided by 'quantifier symbols' ∀x ('For all x') and ∃x ('There are x' or 'There is an x'), followed by ':' ('for which applies'). Sentence 1 in symbols now reads: $\forall a\text{: } c \wedge \neg c$ (contradiction) and sentence 2: $(\exists a\text{: } c) \wedge (\exists a\text{: } \neg c)$.

PROPOSITION LOGIC COMBINES JUDGEMENTS, PROPOSITIONS

From more separate true statements (propositions) you can sometimes deduce another statement as a conclusion. The 'propositional logic' distinguishes different distractions, such as induction, deduction and abduction (***Fig. 50***).

Induction	**Deduction modus ponens**	**Deduction modus tollens**	**Abduction**
Aadorp, Aagtdorp, … and Zwolle are places in the Netherlands. (∃)	If I am in Delft, then I am in the Netherlands. (D⇒N), well, I am in Delft. (D)	If I am in Delft, then I am in the Netherlands. (D⇒N), well, I am *not* in the Netherlands. (¬N)	If I am in Delft, I am in the Netherlands. (D⇒N), well, I am in the Netherlands. (N)
So: All places are in the Netherlands. (∀)	So: I am in the Netherlands. (N)	So: I am not in Delft. (¬D)	So: I am in Delft. (D)

Fig. 50 Some kinds of reasoning

Induction cannot yield a definitive *truth*, but at most a *probability*, how ever many observations you may do.
The example of ***Fig. 50*** counts 4000 places from Aadorp until Zwolle in The Netherlands, but one observation elsewhere, such as 'London is a place in England' may prove that the conclusion is false.

6 LOGIC SUPPOSES A LINEAR LANGUAGE

According to Popper[a], you always have to formulate a scientific conclusion so that everyone can refute it with a counter-example ('falsification').
Any inductive generalizing conclusion is then basically provisional (a 'guess').

The inductive conclusion of ***Fig. 50*** out of the more than 4000 cases proven true ('verifications') shows how a short-sighted generalizing assumption can lead to a wrong conclusion. Nevertheless, induction is generally accepted as a scientific method, albeit under Popper's condition of falsifiability, with sufficient examples for a statistically substantiated conclusion ('reliability') and (except this induction) furthermore a logically sound reasoning ('validity').

Deduction leads to a true conclusion if both first statements (the premisses 'major' and 'minor') are true. The most important scientific application of deduction is mathematics with its axioms and definitions as suppositions declared to be true for the time being during the inference ('premisses').

Here only two examples of deduction are given: 'modus ponens' and 'modus tollens', but there are more logically valid modes. In this examples, the 'major' takes the form of 'In all cases ... (∀)', the 'minor': 'There is a case for which ... (∃) applies'.
Induction has only observations 'There are cases for which applies ...' (∃).

Abduction is logically not valid, but is applied in practice, for example in case of justice:

> Major: "If you have raped her, then I can find your DNA on the spot." (R⇒DNA),
> Minor: "Well, I found your DNA on the spot." (DNA)
> ~~Conclusion: 'So you raped her.'~~

Fig. 51 An example of abduction

Abduction logically produces no truth, but it does offer a possibility (compare ***Fig. 50***: 'so I am in Delft'). This kind of reasoning may help designers in their search for possibilities ('heuristic value').[b] These possibilities, however, are then limited only to the cases that are included in the major-premise.
That is not an acceptable limitation of possibilities for designers.

AN *IMAGE* MAY CONTAIN CONTRADICTIONS

Now back to the predicates. 'True' in one direction can be 'false' in another direction. If you judge 'c' ('charming') while looking at an administrator 'a' from the side, then looking from the front I may judge '¬c' ('*not* charming').

That way a line may appear as a point, *not* as a line. A cylinder is round, but from a different angle of view rectangular, *not* round. A bridge is closed and not closed at the same place and time, depending on the direction of approach by road or water.

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a Popper(1934)The logic of Scientific Discovery(London 1983)Hutchinson

b Dorst (2013) Academic design (Eindhoven) TUE Inaugural speech p5, for example, interprets induction, deduction and abduction as forms of: what!+how?=Solution, what!+how!=Solution, and what?+how!=Solution. The exclamation marks and question marks here have the meaning '!=Determined' or '?=Undetermined'. According to Dorst, in the last form (abduction) the designers also lack the exclamation point for 'how' (what?+how?=Solution). Designing is then the art of questioning both 'what?' and how?' to be answered.
The question is, whether a reference to logical reasoning forms helps or restricts design. In § 23 p48 onwards I will summarize the restrictions.

In many judgements the direction tacitly plays a role. The verbal language supposes one direction by itself, one route in a spatial representation where many routes are possible. With verbal language alone you cannot distinguish directions.
You may introduce a change of direction saying "Another approach is ...", but that does not determine the direction. You need an image to do so.

You can of course make a sentence such as 'The bridge is open, but closed perpendicular to the connection'. With 'perpendicular' (⊥), however, you then forcefully refer to a spatial representation in which directions can be distinguished.
I suspect that 'direction' (approach) is supposed in every word, and therefore *must* refer to an image. A verbal language refers; images show.
That does not exclude that both can be misleading.

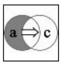
'IF' SUPPOSES LIMITED ALTERNATIVES BY 'THEN'
'Not' refers to an unlimited remainder ('*everything* except…'). 'If' refers to limited, determined cases next to, or after eachother.
The phrase 'If you pick up the other side of the beam, then we can carry it together', presumes the cases of picking up and carrying. The sentence 'If I grind this stone, then I can use it for cutting', presumes the cases of grinding and cutting.

It enables 'intermediate operations' such as making tools in a production process.
In archeology, this is seen as evidence of earlier human presence.
The use of language as an intermediate act, is also a 'tool', as well as body language: laughing, looking angry or questioning.

With a series 'If a then b and if b then c', $(a \Rightarrow b) \wedge (b \Rightarrow c)$, etc., you can weigh whole lines of argument on their consequences, but you can also weigh alternatives ('scenarios'). The logic immediately concludes $a \Rightarrow c$, but then you may forget a necessary intermediate step b. With $(a \Rightarrow b) \wedge ((b \Rightarrow c) \vee (\neg b \Rightarrow x))$ you can create a branch in a tree structure of scenarios. Switches connected in series in a computer ('transistors') also do this, albeit binary ('on' or 'off').

If b='on' ('true'), then the road is open to the next switch c. A bifurcation arises when b 'off' ('false') triggers another switch x (in programming language: 'if b then c *else* x'). You then walk through another branch of the tree. Computer software is seen as an application of logic, but 'true' and 'false' do not play a part. They have been replaced by alternative *actions* c or x. You could call that 'action logic'.

§ 22 'IF' DIFFERS



A NECESSARY CONDITION ('IMPLICATION' ⇒) IS NOT NECESSARY

A necessary condition has alternatives

If you take the car (a), then (c) you definitely will ride. if a then c, a⇒c

If you take the train (x) or (y) the cycle, then you also can ride. x⇒c or y⇒c

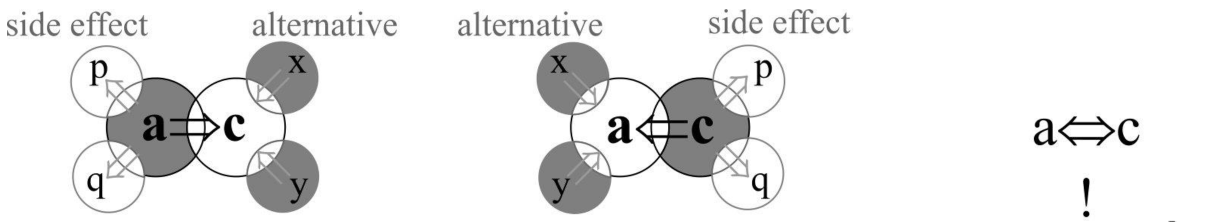
So, taking the car (a) is not a necessary condition to ride.
There are alternatives x,y,...for a.

A necessary condition has side effects

If you take the car (a), then (c) you need a drivers licence. if a then c, a⇒c

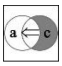
You should also not have drunk too much alcohol (p) and
(q) you also need a warning triangle. a⇒p or a⇒q.

So, taking the car has not the one consequence of needing a drivers licence (c).
There are side effects p,q,...beyond c.



necessary, **sufficient,** **necessary and sufficient condition**

Fig. 52 Different conditions



A SUFFICIENT CONDITION (⇐) IS NOT SUFFICIENT

The logical arrow turns around, but the logical sequence of antecedent 'a' first, from which follows a consequence 'c' remains the same.
The 'sufficient' condition is therefore not a completely reversed necessary condition.

A sufficient condition has alternatives

You can ride (a) if you take the car (c). only then a if c, a⇐c

You can also take the train (x) or the cycle (y). a⇐x or a⇐y

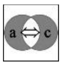
So, the ability to ride is not a sufficient condition ('guarantee') to take the car (c).
There are alternatives x,y,... for c.

A sufficient condition has side effects

You can take the car (a), if (c) you have a driver's license. only then a if c, a⇐c.

Instead of the ability to take the car (a), you can also identify yourself (p)
or get a job (q) if you have a drivers licence. p⇐c or q⇐c.

So, to be able to take the car (a) is not the only thing guaranteed by a drivers licence.
There are side effects p,q,…for a.



A 'NECESSARY AND SUFFICIENT CONDITION' (⇔) EXPRESSES EQUIVALENCE

With '⇔' ('equivalence') 'a' and 'c' say the same 'in other words'.
That is not entirely useless. In mathematics '=' is also very useful.

A CAUSE IS A CONDITION, BUT A CONDITION IS NOT ALWAYS A CAUSE

'If house, then foundation', or its double negative equivalent: 'No house without foundation' concern a timeless result, not the *action* in time *causing* that result.
The action is eventually *motivated* by such a result: 'If you build a house, then you first have to make a foundation, *because* no house without foundation'.

Compare this with what I earlier called 'action logic' in computer software.
'If you let it go, then it falls', suggests a causal sequence, where the previous example was purely conditional.
A foundation is not the *cause* of a house. It is a *practical condition* for a house.

The linear language of logic often refers to time. In a⇒c is 'a' the *ante*cendent and 'c' the con*sequence*. '*Then*' in 'if…*then*', has a temporal connotation.
'Not without', however, sounds purely spatial, and the truth table of ***Fig.* 49** p106 shows *spatial* equivalents in order to ex*plain* logical operators by overlapping sets.

I defend: 'No change without difference' or 'No time without space'.
After all, a process must 'take *place'*. I would like to change 'everything changes' (attributed to Herakleitos by Plato as 'everything disappears', or 'everything flows') to 'everything differs'. That allows me to represent 'cause' as a special case of 'condition'.

Assume we read in the newspaper:
"The collision was *caused* by the driver losing control." That sounds plausible, until an extraterrestrial descends next to us and says: 'Nonsense! A collision is caused by two objects moving towards each other on the same line! '
If he is right, the newspaper is wrong, because if that was not the case, there would have been no collision, even though one of the drivers had lost control of the wheel.

But there are still other circumstances to think of, where one of the drivers loses control over the steering wheel without causing a collision.
If the cars had stopped, if the petrol had run out just before the collision, a breakdown in the engine occurred, a gust of wind had blown one of the cars off the course, an earthquake had opened a deep ravine between them, and so on.

If in that sense all conditions for a collision are met, then the '*last condition added'* (that a driver loses control over the wheel) is called the 'cause' of the collision.
Every 'cause' is a condition that something can happen, but not every condition is also a 'cause'. A negative 'cause of failure', however, is easier to determine if one condition of the many falls away in a process you expected to function normally.

6 LOGIC SUPPOSES A LINEAR LANGUAGE

DESIGN SUPPOSES MORE CONDITIONS THAN ONE

Every cause is surrounded by many other conditions that must be fulfilled in order to make something *possible*.
The last added condition is often called 'cause' ('the roof made the house').

One 'if ... then' strain is not sufficient for use in the multidimensional space.
There are all kinds of preceding roots (conditions) and subsequent branches (consequences): a 'tree of causality', or even a forest full of such trees together.
That enables imagining rare possibilities.

There are always many conditions (side-by-side, 'horizontally') at the same time, each with their own 'vertical' context of trunk and tree structure, in order to make something happen (or make it at least possible).
That's what designers, managers and ecologists know about.

A linear language often ignores the other 'side-values' ('c' if 'a' or 'p' or 'q' or ...) as if they remain the same in all cases ('ceteris paribus').
These are all side streets that disrupt the line of argument.
You can then add 'p ... z' as 'sufficient conditions' at 'a' in the logical formula, but how do you know whether this is actually 'sufficient'? Their number is basically infinite.

If you have enough seed, sun, water and minerals, you can grow a tree … if it is not eaten by animals or fungi, cut down, catches fire, and so on. These are all positive (if ... then) and negative (if not…then) conditions that do not yet result in a tree, but make it *possible*. What else is possible under these conditions? Which unnamed, but easy to realize conditions can I add? What is then more possible? Typical designer's language.

LOGIC OVERLOOKS MULTIDIMENSIONAL CONDITIONS OF POSSIBILITY

'If a then c' ($a \Rightarrow c$), and 'only then a if c' ('$a \Leftarrow c$') are assertions that can only be true or false. What is true must be possible, but what is possible still does not have to be true.

It can be *made* true. Truth claims concern a small subset of a much larger set of possibilities. These possibilities are largely untrue or very improbable (***Fig. 3***, p15), but just that is the field of designers. Designers are looking for possibilities that are not (yet) true or probable, otherwise they only make copies, reports or prognoses.

Before a possibility is realized, you cannot say: 'It is true that it is possible', because truth is a subset of possibility just as cows are a subset of animals, and you cannot say 'An animal is a cow' either.
You can say, 'It is possible that it is (or becomes) true', just as you can say 'A cow is an animal'. This applies in general ($\forall$ cows: cows$\Rightarrow$animals).

Not for all animals applies 'if animal then cow' ($\neg\forall$ animals: animals$\Rightarrow$cows).
In a special case you may still say: 'There is an animal for which applies: 'if this is an animal, then it is a cow' ($\exists$ animal: animal$\Rightarrow$cow).
The reverse '$\exists$cow:cow$\Rightarrow$animal' is trivial. Our use of the word tacitly supposes itself.
In the meaning ('semantics') of 'cow', '$\forall$cows: cow$\Rightarrow$animal' is already decided.

MODAL LOGIC MAKES POSSIBILITY SUBORDINATE TO TRUTH

If you are looking for conditions to make something possible, the 'modal logic' offers two new operators (□ and ◊). If a statement 'c' (for example, 'nothing goes faster than light') must be true in all circumstances, then 'c' is necessarily true ('□c').
In modal logic 'in all circumstances' reads as the even broader 'in all possible worlds[a]'.

An assertion 'c' (for example 'it is freezing') being not true now and here (¬c), can be true in other seasons, in other parts of the world or in any possible world.
Possibly 'c' (◊c) is defined as 'not necessarily untrue' (¬□¬c).[b]
Impossibly c (¬◊c) is therefore 'necessarily not c': □¬c in any possible world.

'Necessarily c' (□c) then applies in all possible worlds and 'possibly c' (◊c) in some.
Every assertion 'c' about an impossible world is itself impossible (¬◊c), and must therefore by definition necessarily not be 'c': '□¬c'.
Then ◊c = ¬□¬c is limited by necessity, subordinated to the truth value of necessity.

The modal verb 'must' (the operator □) is of course subject to a wide range of explanations[c], and there is a kind of modal logic for every opinion.
A common view is the 'alethic' vision: there are no worlds that do not meet the logic, our idea of 'being' ('metaphysical') and the generally applicable laws of nature.
These conditions are also only 'descriptive' in our linear verbal language.
In images perhaps there is more possible.

The modal logic includes different systems such as 'K', 'T' and 'D'. System 'K' includes all propositions of propositional logic plus □ and ◊. System 'T' adds that if p is necessary, p is always true (□p⇒p). From this it can be proven that what is true is at least possible (p⇒◊p, that starts to look like ***Fig. 3*** p15). That is not yet fixed in 'K'.
System 'D' adds to 'K' that what is necessary is also possible (□p⇒◊p).

A logical claim, however, can only be true or false.
The statement a⇒◊c ('If a is true, then c is possible') then contradicts ***Fig. 3*** p15 (the view that truth is a subset of practical possibilities).
If 'possibility' is a modality, then a part, and therefore 'truth', is also a modality.

A modal logic that understands 'truth' itself as modality, cannot take formal logic as a starting point and must look very different. This is certainly not to say that logic is useless, but it has its limitations and it is not 'a priori' innate.

a Introduced by Leibniz(1710)Essais de Théodicée sur la Bonté de Dieu, la liberté de l'homme et l'origine du mal(Amsterdam)Changuio. In order to answer the always pressing question why an infinitely good and almighty Creator has allowed evil into the world (theodic), Leibniz argues that He has chosen the 'best of all possible worlds'. Leibniz also invented the infinitesimal calculus (integrating and differentiating), in other words, the useful handling of infinities in mathematics gave him a reassuring analogy in religion.

b Hughes(2005)A new introduction to modal logic(Abington)Routledge p17.

c Divers(2002)Possible worlds(Abington)Routledge p4. If possible worlds 'must' be logical (relatable), credible (doxastical), existable (metaphysical), nameable (analytical), knowable (epistemical) or tolerable (deontical), then this requires less or more logical suppositions about the possible in the modal logic. Divers does not mention the condition 'operating' that is presented here as 'practical'.

§ 23 DESIGN REQUIRES MORE DIMENSIONS THAN THE LOGIC SPACE

IF TRUE, THEN POSSIBILE

Modal logic makes possibility subordinate to truth, whereas what is true must certainly be possible, and that is more than word-bound 'not necessarily not'.

Current logic is limited to 'truth values'. It does not involve ⊥ relationships.
The apparent contradiction (the perpendicularity paradox of ***Fig. 5*** p17) then is considered to be inadmissible.
Necessarily 'if a then b' also suggests that there is no alternative to b.

The common logic focuses on conjunctions and adjectives, predicates instead of the central verb (or it had to concern the actionless 'is' that assumes a metaphysical 'being' in assertions, propositions).
The 'being true' comes first, the 'making true' is left out of consideration.

The assumption that computer programs are always based on this logic is not correct. Their command 'if ... then ...' is an action choice without truth value.
The transistor opens the possibility a or b on demand.
That has nothing to do with truth.

Such reductions block design thinking.
How to construct an action-oriented modal logic, in which 'truth' itself is a modality, I will leave to others, but 'practically possible' I can define for the time being as 'what can be realized through action'. That requires a new operator.

A non-language-bound, and therefore not assertion-bound, but action-related practical possibility condition, is definitely something else than a truth condition.

I write that 'practical condition' as c ⇓ a ('c supposes, is possible by a'). For example: Culture ⇓ Biotics ⇓ Abiotics. 'Is supposed in' or 'makes possible', 'enables' then gets the symbol ⇑: Abiotics ⇑ Biotics ⇑ Culture.

These operators *include* the truth-valued implications: Culture ⇒ Biotics ⇒ Abiotics, if there are no alternatives (necessity). According to ***Fig. 52*** p110, however, there are explicitly other alternatives x, y ... instead of 'a' making 'c' *possible*.
Four exercises in the next section should demonstrate when ⇓ and ⇑ are required.

That 'c ⇒ a' is the only (or strictly necessary) possibility for c or a is premature.
Such a linear 'necessarily true' is frustrating for designers in their search for nonlinear 'perpendicular' possibilities. Unfortunately, this 'necessity' is often assumed as self-evident by 'scientifically trained' advisers and experts.

If a designer wants to present a possibility as feasible, then the assertion '∃ possibility: possibility ⇒ truth' is not a solution, because the truth of that statement should already *include* the possibility (***Fig. 49*** p105). '∃ possibility: possibility ⇐ truth' is also not possible, because that possibility is not (yet) true (realized).

I am here on the slippery path of a 'meta language'. I am talking *about* the language use of truth and possibility, but in the same language and logic with an appeal to the same words 'truth' or 'necessity'. According to Russell, that may lead to contradictions.

According to the perpendicularity paradox (***Fig. 5*** p17), however, a meta-language is conceivable as 'perpendicular' to the language discussed.
That logical contradiction ('⊥') then only *seems* a contradiction ('paradox').

The common logic does not apply to images or representations that are not covered with words. This is important for designers.
'If ... then ...' is assumed in every design, but the logical implication has a meaning that is inadequate for designers. It is discussed below with four 'exercises'.

The modality of common logic is not desirability or possibility, but 'truth'.
What is 'true' is certainly possible, but not everything that is possible is also true.
Truth (or more general probability) is thus a part of possibility in ***Fig. 3*** p15.

Because you cannot speak of 'truth' without an *assertion* that can be true or false, it is bound to verbal language. However, words generalise. So, different images are covered by one word and a word evokes different images in different people.

An assertion is 'true' if this claim corresponds to a reality that can be confirmed or repeated by others. This correspondence passes a considerable number of barriers deserving doubt about verbal communication (p70). If truth can only be expressed in words, then a photograph is not logically 'true'. The claim 'This picture covers reality' may be 'true', but that is a half-truth, because a picture never completely covers reality.

EXERCISE 1 LAYERS OF CONTEXT DO NOT IMPLY (⇒), BUT SUPPOSE (⇓) EACH OTHER
Before there is a design, before there is an *object* to think about afterwards, there is a *context* making a design possible. I distinguish the following layers of context (***Fig. 13*** p37 with primitive definitions in brackets):

governance (management, administration, steering organizations),
culture (a set of common assumptions and provisions),
economy (livelihood through transport and exchange of goods and services),
techique (providing improbable opportunities),
biotics (a set of cells with a locally entropy-lowering metabolism) and
abiotics (matter with increasing entropy).

They may have some conditional stacking (***Fig. 7*** p24).
Which kind of conditionality is applicable here?

The necessary condition cuts off possibilities
Suppose first: 'governance ⇒ culture ⇒ economy ⇒ technology ⇒ biotics ⇒ physics'. This means: 'if governance then culture, if culture then economy' and so on. In the first glance I indeed can hardly imagine governance without a shared culture ('not without' is the same as '⇒', see ***Fig. 49*** p105).

Governance after all implies a collection of shared self-evident assumptions: a language, agreements, a division of tasks, availability of facilities and their rules.

However, a dictatorial management or governance with coercion or death threat does not presume all that. Also a governance that withholds information does not share its concealed assumptions in a common culture. And what about steering robots? So I still can imagine a governance without culture.

After that, I can hardly imagine a culture without economy: 'livelihood through transport and exchange of goods and services'.
Without that, every culture will go under. Culture is then according to ***Fig. 49*** necessarily a subset of each economy (culture ⇒ economy).

However, a culture whose livelihood falls away, may fall back in hunting and collecting (perhaps even robbery) with direct individual consumption and thus without economy, but still with a (slightly changed) culture (keeping language, religion, etc). Children also do not have to be part of the exchange of goods and services (labor) by transport for many years.
The elderly do so on the scale of the family, for the time being.

This also applies to sick people and families who cannot provide for their livelihood. It may be provided outside of them by an economy and a care system on a larger scale keeping a family culture intact. The scale on which you give 'economy' and 'culture' a meaning therefore plays a role. Respecting the scale paradox (***Fig.*** **6** p18) you cannot change the level of scale in an argument. So I keep reasoning at one level of scale.

This way I can imagine a culture without economy on a family scale.
The implication 'governance ⇒ culture ⇒ economics' does not apply completely if you keep the same level of scale in the argument.
For the following layers of context I can also come up with falsifying examples.

The sufficient condition is not sufficient
Then take: 'governance ⇐ culture ⇐ economy ⇐ technology ⇐ biotics ⇐ physics'.
This means: 'governance if culture', 'culture if economy', and so on.
That is possible, but not necessarily true. The inverted implication ⇐ therefore is not practical if you want to leave unrealized (untrue) possibilities open to designers. Culture may make governance possible, but not necessarily.

If you take 'bringing cups to the kitchen and do the dishes' as a part of 'living by transport and exchange of goods and services', then a family also has a family economy, but it does not necessarily produce a family culture.
This applies entirely to hermits, but there are also examples from cultural anthropology, and the question is whether you can speak of 'culture' in an ant colony.

An ant colony in any case clearly has a form of 'livelihood through transport and exchange of goods and services'.[a] So I can imagine an economy without culture. This way I can also come up with '*However ...*' examples for the other logical relations in the series (falsifications) where the 'sufficient condition ⇐' does not suffice.

Design requires a practical condition
I prefer 'Governance ⇓ culture ⇓ economy ⇓ technology ⇓ biotics ⇓ physics': 'governance possible by culture', 'culture possible by economy', and so on.
You may exchange 'possible' by 'supposed' (litterally under-stood ⇓) if it concerns the possibility of imagination. In the opposite direction you can use ⇑ ('culture makes governance possible' or 'enables imagining governance'). In a special case (∃) you can still hold '*this* governance necessarily implies a culture' (⇒).

These possibility conditionals ⇓ or ⇑ include ⇒ or ⇐, without becoming ⇔.
Releasing the necessity from 'if ... then' is a liberation for a designer who seeks possibilities instead of truths or necessities. The tacit, but common, assumption of truth and necessity, plays the leading role in every communication.
A good designer questions current assumptions and only comes up with something new if some assumptions are omitted or replaced ('reframing').

The question 'can I imagine x without y, but with z?' increases the possibility of imagination.

EXERCISE 2 LAYERS OF OBJECT DO NOT IMPLY (⇒), BUT SUPPOSE (⇓) EACH OTHER
The previous exercise concerned layered characteristics of the design *context*.
This exercise involves several 'layers' of the design-*object* (***Fig. 7*** p24):

content (material, substance which can take form),
form (a durable and thus recognizable state of dispersion),
structure (a set of separations and connections),
function (directed operation),
intentions (focus on a *field* of goals).

A *design process* does not have to follow that sequence itself.
There are as many design methods as designers. One starts with the material or the form ('means-oriented design'), the other with the function or intention ('goal-directed design') and each method then jumps back and forth between all these layers in order to constantly change them into a coherent concept.

Its *execution*, however, starts with gathering materials, then give them a form, a structure in order to keep that form, detailing parts for different functions and at last check if they fulfill the intentions of users.
On page p24 I assumed a 'conditional' sequence. Is'nt it simply a logical sequence?

---

a An exchange of goods and services is not necessarily tied to a culture with valuation, money, agreements and so on. In nature you will find numerous examples where goods and services are exchanged without a trace of what you can call culture in the sense defined here.

The necessary condition (⇒) is not necessary
Assume first the implication: content ⇒ form ⇒ structure ⇒ function ⇒ intention. This is not right. Liquid or gas have a content, but not necessarily a determined shape keeping form by structure. There are structured forms without function or intention.

This applies the more so, for the content of our imaginations.
They do not have a stable form, structure, function or intention.
In order to 'place' them next to other images, we can *give* them a form, a dispersion in an imaginary space considering possible structures, functions and intentions.

Cicero[a] also sequentially 'placed' the parts of his argument as a memory support in different rooms of an imaginary palace, considered different routes, chose one for his speech and then could remember that walk during his speech.
A designer can even leave rooms empty for the time being, giving them a form without content, without choosing materials, structures, functions or intentions yet.

This may be characteristic of any design skill.
A design object nor its components exist before it is designed.
Considering different possible combinations of variable components, you can finally choose the best coherence, and make a proposal for realization.

The realisation itself does not get this sequence with a logical necessity either.
The collected material does not necessarily get a form. A form does not necessarily have a structure, and so on.

The sufficient condition (⇐) misses opportunities
Assume then the 'sufficient condition': content ⇐ form ⇐ structure ⇐ function ⇐ intention. A content then necessarily exists in so far it has a form, and a form only if it has a structure and so on. This cannot be true for the imagination of a designer.

A designer may draw a shape (contour), still without any idea about the structure keeping it in form. S(he) can describe a structure that still may have all kinds of functions, and so on. These representations exist only in thought, and that applies to every possibility that has not yet been realized, even if it is not realizable at all.

Truth logic has room for what is not true (an indefinite rest), but it is not a tool to explore that rest as a field of possibilities.
To explore what is not (yet) true, requires a different kind of conditional.
You can guess that my preference for design logic again comes down to the use of ⇓.

a Cicero(-55)De oratore II 531(Cambridge Mass 1959)Harvard University Press Loeb.Heinemann p465

EXERCISE 3 LEVELS OF SCALE DO NOT HAVE A LOGICAL OR CONDITIONAL SEQUENCE
This exercise involves several 'levels' of the design-*object* (***Fig. 7*** p24):

…
10m (nominal radius between 30m and 3m)
3m (nominal radius between 10m and 1m)
1m (nominal radius between 3m and 0.3m)
…

Fig. 49 on p105 shows a ⇒ c as sets a and c, where 'a only true within c'.
You then could bluntly think that 'c' should be larger than 'a'. So, 1m ⇒ 10m, reading 'if there is 1m, then there must be 10m' (so, the universe is infinite).
In that sense, however, 10m ⇒ 1m is also true, so, 10m ⇔ 1m, but that is certainly not true. What is wrong in this inference?

The attribute of c is not *larger* than a, it is *more general* than the attribute of a.
Charming (c) is not *larger* than an adminstrator (a),
c only *extends to more persons* than administrators.

This unveils a tacit supposition on p105: c is not only an attribute, it is an object *with* that attribute: a charming *person*. Since an administrator (a) is implicitly a person, the logical operator connects objects of the same type (Ryle, § 21 p105).
In cow ⇒ animal the type is implicitly the same (both are organisms).

So, you may say 10m ⇒ m ('if 10metre, then metre'). That seems trivial, but '10m' or 'm' cannot be *true* of *false* without indicating objects with that size. The mentioned sizes are their *attributes*. Adding an object, it could read building_{10m} ⇒ window_{1m}, but that is only true with a quantifyer (∃): 'There is a case where building_{10m} ⇒ window_{1m}'.

Here, the implication with a possibility value (⥣) comes in: you may say building_{10m} ⥣ window_{1m} ('if building_{10m}, then window_{1m} is possible' or 'building_{10m} enables window_{1m}'). That is a useful conclusion for design. The reverse, however, is also possible. So, it does not determine a direction of sequence in levels of scale.

For design and imagination, however, it may be useful to alternate the level of scale if both large ⥣ small and small ⥣ large. It is a kind of changing context (Hertzberger's advice on p279). Large ⥣ small may be useful for probable possibilities (determined by statistics) and small ⥣ large for improbable ones.

EXERCISE 4 MODALITIES ARE LOGICAL IMPLICATIONS.
Fig. 7 p24 states (true ⇒) probable ⇒ possible ⇒ imaginable according to ***Fig. 3*** p15. That allows stating 'desirable' ⇒ imaginable, the problem field as probable∧¬desirable and the field of aims as desirable∧possible∧¬probable.
So, the purely logical operators are sufficient for modalities.

POSSIBILITY ⊥ TRUTH

Sets are usually drawn as 2D Venn diagrams. Stolk[a] proposed to draw possibilities stacked 3D as layers that eventually can be removed or replaced.

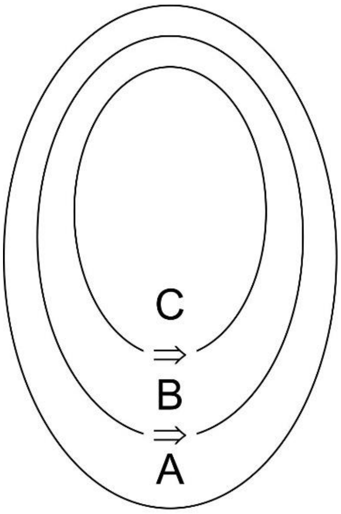


Fig. 53 Necessarily *C ⇒ B ⇒ A*

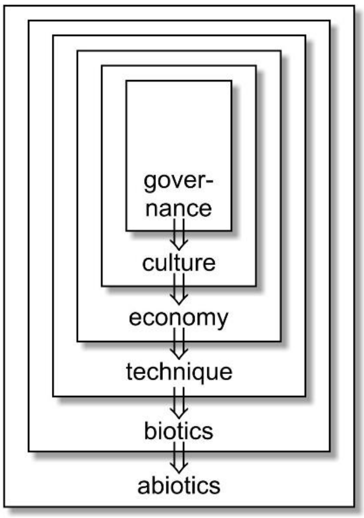


Fig. 54 Contextlayers *supposing⇓ lower layers*

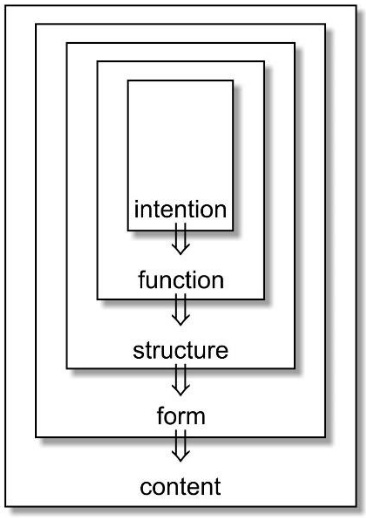


Fig. 55 Objectlayers *supposing ⇓ lower layers*

In 'If B then *necessarily* A' (B ⇒ A), B is only true as a subset of A.
So, B is necessarily part of A. There is no alternative for A.
'If B then A *possible*' (B ⇓ A), or 'A enables C' (B ⇑ C), *does* leave alternatives for A.

Linear verbal language neglects possibilities ⊥ the line of reasoning.
There may, however, exist possibilities beyond B ⇒ A (***Fig. 52*** p110).

For example, if A represents an abiotic basis, as a necessary condition for life phenomena B, which in turn are a necessary condition for culture C: C ⇒ B ⇒ A, then the 'ABC model' of ***Fig. 8*** p26 applies: subsets trapped in the flat plane.
B cannot be replaced by the alternatives x, y, etc. of ***Fig. 52*** p110.

If you concern technique as an extension of the biotic layer B, then it may enable more than the old C.
So, *distinction* may open new possibilities (a well known experience by designers).

If C itself is specified and subdivided into governance, culture (in a narrow sense), economy and techno*logy* (***Fig. 54***), then you can no longer propose them as subsets or necessary logical implications (⇒). ***Fig. 54*** and ***Fig. 55*** therefore give a spatially constituent image of exercises 1 and 2 in 'layers' of sub-positions(⇓).[b]

Moreover, exercise 1 (p115) demonstrated the improbable possibility that a dictator removes, replaces or transforms the layer 'culture' in ***Fig. 54***.
Exercise 2 (p117) demonstrated that there are intentions possible without function.

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a Stolk(2015)Een complex-cognitieve benadering van stedebouwkundig ontwerpen(Delft)Proefschrift TUBk Urbanism p176.
b Because sets in relation to truth conditions are always drawn with smoothly curved lines, I have distinguished the conditions of their possibility as rectangles. This is unfortunately not consistent with the symbol for necessary (□) in modal logic.

§ 24 LOGIC SUPPOSES A DESIGN

Fig. 7 p24 distinguishes modalities, levels of scale, context layers and object layers of design. Logic then exhibits the following design features.

Modality ⇓ ((true⇒probable⇒possible⇒imaginable)∧desirable)
The modality of logic is **truth**.[a] Anything true is probable, but not every **probability** is true. The set of truths is a subset of the set of probabilities.
The set of probabilities is a limited subset of the set of **possibilities**, but not every possibility is probable. The limitations of that subset are selected variables.

Logic is truth based and 'truth' is bound to verbal assertions.
These are linear by nature. In an image, a conclusion ⊥ that assertion may contradict the assertion. Such conclusions are blocked by linear logic.
Design requires a possibility-based conjunction.

Anything true must be **imaginable**, but not always desirable.
If it is not desirable, then you have a problem, or a field of problems. If it is desirable and possible, but not probable, then you have an aim, or a field of aims. (***Fig. 3*** p15)

Levels of scale ⇓ (…, 10m, 3m, 1m, …)
In the predicate logic, you may assume that ¬object supposes a context, an undetermened rest, or antecedent⇒consequent implies object⇒context.
The consequent (eg animal) should be more general than the antecedent (eg cow).

In the proposition logic the major (eg 'If I am in Delft, then I am in the Netherlands) should be more general than the minor (eg 'Well, I am in Delft').
So, logic covers any level of scale.

Context layers⇓(Abiotics⇑Biotics⇑Technique⇑Economy⇑Culture⇑Governance)
The **abiotic** conditions of ***Fig. 13*** p37 are largely recognizable in logic as a design. These are supposed in the biotic and cultural conditions that follow them as further specifications. The logic itself does not have biotic specifications.

Perhaps biology requires some specifying additions to common logic, but **technique** certainly requires a possibility operator. That should enable **economy**, **culture** and **governance**, but these still may require even more specifying additions of their own.

Object layers ⇓ (Content ⇑ Form ⇑ Structure ⇑ Function ⇑ Intention)
Conjunctions and rules connecting predicates and propositions are the **content** of logic. The subject-predicate distinction, however, hides the crucial verb in the predicate. The action and its result is stabilized as a 'property' of the actor (subject).

This distinction obstructs an understanding of verbal language as a human design. Any verbal expression is an interfunctional means for cooperative action at last. The verb is the core of the sentence, eventually flanked by other expressions specifying the active subject *and* the result of the action: subject-verb-result.

---

a Modal logic (p92) introduces a possibility operator, still subordinate to truth. Possibly 'c' (◊c) is defined as 'not necessarily untrue' (¬□¬c)

The **form** is linear, and the **structure** is no more than a strict sequence of connections and separations. The **function** is correcting verbal language, including mathematical language, without any other **intention** than to make proper reasoning possible.

LOGIC CAN BE CONSTITUTED

Is logic constitutable according to ***Fig. 13*** on p37? It reads:

A	difference	⥣ change	⥣ coherence	⥣ selection	⥣ combination	⥣
B	metabolism	⥣ regulation	⥣ organization	⥣ specialization	⥣ reproduction	⥣
C	information	⥣ security	⥣ affection	⥣ identity	⥣ influence	

Logical variables are indeed **different** assertions.
Logical operators **change** their meaning (eg $\neg$) or make a new **combination** (eg $\Rightarrow$).
The **selection** is true or false.[a] What, however, about the *coherence*?

Logic allows to say 'If a man is an animal, then the earth is round'.
If both assertions are true, then the logical implication '$\Rightarrow$' is true (***Fig. 49*** p105), but it does not *make sense*. The claims must have some **coherence** with each other in order to give a meaningful *combination* as a result.

Fig. 49 p105 therefore added a condition: 'a and c must contain an effect on the same variable x' (antecedent a = f_1(x) and consequent c = f_2(x)).
Moreover, f_1 and f_2 should be also of the same 'type' (Ryle, see note p105).
You cannot connect red and round in the assertion 'a $\Rightarrow$ redder than round', even if it concerns a function of the same x. 'Redder than round' is not 'imaginable'.
So, with coherence, the logic is constitutable, and imaginable as an abiotic design.

If biology requires more specifying additions to common logic, then you may first question whether **metabolism** can get some meaning in logic. Metabolism primarily supposes some difference of combination (by logical operators). I will not try to answer this and the next raising questions, but already I proposed $\perp$, ⇓, and ⥣.

Let us for the time being conclude that the constitution of logic ⇓ abiotic conditions.

Logic gives our linear, verbal language the exactness that is required for mathematics (a part of that language, limited to quantifyable qualities, their conjunctions and some verbs). Since Russell[b], the general view is, that mathematics can be founded on logic.[c]

a In the case of a multivalent logic with more possibilities than 'true' or 'false' (no excluded third), selection must also play a major role. It also plays a major role in other designs, because the object that has yet to be designed is vague in the beginning. There is still a margin between 'indeed' and 'not'.
b Russell(1903)The Principles of Mathematics(Cambridge)University Press §1 p1.
c The old-fashioned thorough and decent German atlas of Reinhardt;Soeder;Falk(1977)dtv-Atlas zur Mathematik(München)Deutscher Taschenbuch Verlag therefore begins with logic.

7. MATHEMATICS SUPPOSES REPETITION

The title of this chapter is a statement I want to test in four examples of mathematics. Geometry and probability theory suppose that cases can be reduced into numbers of repeated equal units. Geometry reduces objects to measures, probability theory reduces differences to deviations from a central number.

An exact *repetition* of operations on the result of previous operations ('iteration'), however, may yield infinite variety, but this variety is still smaller than that of nature. It demonstrates how small differences can have major consequences.

A learning neural network as supposed in our brains can be mathematically simulated by repeated *adjustment* of the repetition. Although I understand step by step what happens, I still do not understand what happens in total at last.

Reality always overtrumps us with exceptions.
The quantitative reduction of differences and changes requires continuous adaptation and expansion of different calculation rules, series of linked operations.[a]
That variety of supposed operations, however, still does not cover everything you easily can see happening around.

a Abramowitz;Stegun(1965)Handbook of Mathematical Functions(New York)Dover needed already more than 1000 pages.

§ 25 GEOMETRY ENABLES A LANGUAGE IN MORE DIRECTIONS

EUCLID'S FIRST DEFINITIONS HIDES MANY SUPPOSITIONS

Euclid's first definitions for geometry (ca 300 BC) disappoint me.

The first definitions of Euclid	their substantial suppositions
"a A point is that, which has no part."	'being', 'having', 'part'
"b A line is a length without breadth."	'length', 'without', 'breadth'
"c The ends of a line are points."	'end', the plural form of end**s** en point**s**
"d A straight line is a line which lies evenly with the points on itself."	(this also applies to curves) 'lying', 'evenly', 'on'

***Fig. 57 The first four definitions of Euclid*[a]**

The used words 'part', 'length' and 'breadth' presuppose already the straight line that has to be defined. The definition of 'straight line' is beyond me, but that may be due the translation from old Greek.[b] Anyhow, Euclid needs 11 substantial suppositions.

I take the suppositions of 'a', 'the', 'that', 'which', 'no', 'without', 'with' for granted as not yet substantial words, but I would avoid the tacit metaphysics of 'is' and 'has' in a definition. These verbs do not refer to real *actions*. ***Fig. 58*** is my preliminary attempt to formulate practical definitions using actions (verbs) based on 'difference'.

GEOMETRY CAN BE FOUNDED ON LESS SUPPOSITIONS

This attempt is flawed and incomplete, but it is sufficient to conclude that there are starting points possible with less suppositions than the Euclidean.

Practical definitions	their substantial suppositions
a 'A point' differs the least.	'differing', 'the least'
b 'Two points' differs more and directs.	'more', 'directing'
c 'Contiguous points' differs the least more.	
d 'A line' directs contiguous points.	
e 'A straight line' directs the least.	
f 'Parallel straight lines' differs and directs the least	
g 'Perpendicular straight lines' differs and directs the most.	'the most'

Fig. 58 Practical definitions

The *names* between '...' represent no more than a *quality*, still without any other meaning than defined. They already may have a plural form, but the defining verb is singular in order to avoid supposing a plural form still to be defined.
A quantity concept arises only through further distinctions.

An observed object is enclosed in all directions by differences (***Fig. 5*** p17).
A lateral observation supposes an 'inward' or an 'outward' *direction* from inside into outside or from outside into inside. That may lead to an opposite conclusion about the object (hollow or convex), but it does not change the 'difference from the rest' itself.

A frontal (⊥ lateral) observation simply concludes 'something differs from the rest'.
The static-independent concept of 'difference' stabilizes the verb into a noun.

a Euclides(ca-300)The elements, definitions a-d in Greek mathematical works (Cambridge Mass 2002)Harvard University Press Loeb p437. See also Dijksterhuis(1929)De elementen van Euclides(Groningen)Noordhoff p111

b Ευθεία γραμμή εστιν, ήτις εξ ισου τοις εφ εαυτής σημείοις κεῖται.

The verb does not even require an object yet 'of which' the 'rest' can differ, because 'to differ' is a *pre*condition for 'object'.

Something differs first, before it is recognized as an object ('something different').
A 'different object', then introduces the plural of 'two objects', but 'least', 'more' and 'the most' still do not have a *quantitative* meaning. They distinguish here only the difference // to the boundary of any object (least difference), and ⊥ (most difference).

A point is an object without inside. A point does not suppose any direction or difference in direction. It has no other difference than just 'being different' (***Fig. 58***a). Differing and directing are still one observation.

Two points differ *and direct* (***Fig. 58***b), but 'direction' gets only a meaning by 'difference in directing' (three points).
The practical definitions a and b of ***Fig. 58*** simultaneously enable to develop 'distance' (as a primary difference) and 'number' (in steps next to a and b, not defined here).

In c, the term 'contiguous' is defined (better: 'constituted', see p35).
In b, c and d, the term 'more' perhaps raises the question 'than what?' It lies in the language, the concept of definition and its constitution that the answer must be 'than the foregoing'. That should then be a prior supposition not yet constituted here.

In e, a reduced meaning of 'directing' is used.
'Directs the least' refers to the 'least number of directions' (here momentary understood in a quantitative sense). In everyday language, a straight line is the most directing, but you should bear in mind that it *limits* directions most.
In f the plural form is still defined as a singular action of differing and directing.

In g, 'perpendicular' is defined as 'most' difference in direction.
'To differ' is a verb. It has no active subject or object. It supposes, however, that opposite directions (180^o) are again the *least* different to each other. This supposition would require, amongst others, an addition to the practical definitions, but so far it is sufficient to conclude that there are other possible starting points than the Euclidean.

From the concepts of 'differing' and 'directing', the word 'perpendicular' (⊥) can be constituted after just a few definitions, an essential condition for placing and describing objects numerically with the 'linear algebra' in 'analytical geometry'[a].

ANALYTICAL GEOMETRY REDUCES FORM INTO NUMBERS AND OPERATIONS

If you draw two ⊥ straight lines ('coordinate axes' x and y) crossing in a point called 'origin' in a plane (0 0 in ***Fig.59***), then you can describe the relative position of each point 'p' by two numbers ('coordinates' x_p and y_p): its shortest distances ⊥ to x and y.

a The operations of analytical geometry are called 'linear algebra'. The conventions of linear algebra may differ from other algebra's. For example, the normal multiplication a*b is usually written as ab, omitting the multiplication sign. In lineair algebra, however, the dot product sign • between matrices is usually omitted, even though its meaning is not the usual multiplication, but a *sum* of multiplications. That is why I will not omit the dot product sign in this text. There are more instances where I will offend the professional conventions of linear algebra, such as using [ ] for vectors.

A straight line between two points requires 4 numbers. If a line starts in the origin, then xp and yp at the end are sufficient in order to calculate its length (according to Pythagoras) as $\sqrt{(x_p^2+y_p^2)}$ and its angle ('arc') with the x-axis as 'arctan(y_p/x_p)'.

It is common to display related numbers in a table (a 'matrix') of rows and|or columns between brackets [ ]. A kind of added multiplication (the 'dot product' •) of a 'transformation matrix' with columns of coordinate numbers, allows to enlarge or rotate a group of points that may produce a figure (a triangle in ***Fig 59***).

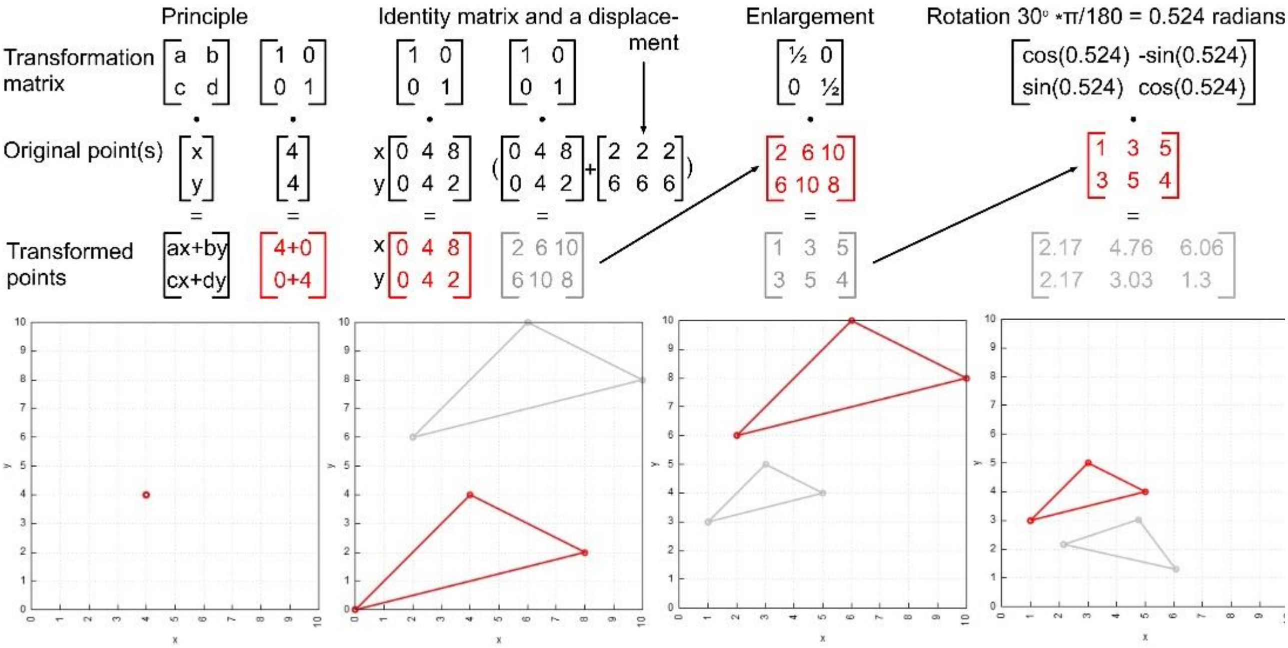
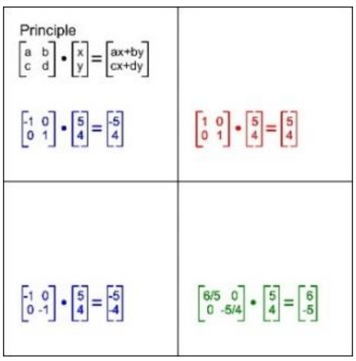


Fig. 59 Transforming three points of a triangle

If the transformation matrix has the form $\begin{bmatrix}1 & 0\\0 & 1\end{bmatrix}$ ('identity matrix'), then the result is identical. You may add more original point coordinates (columns) to be transformed. *Displacement* is adding a change of x and y, but *enlargement*[a] requires a change of the transformation matrix itself. So does *rotation* in an even more sophisticated way.

Mirroring is just putting proper minus signs in the transformation matrix (***Fig. 60***).



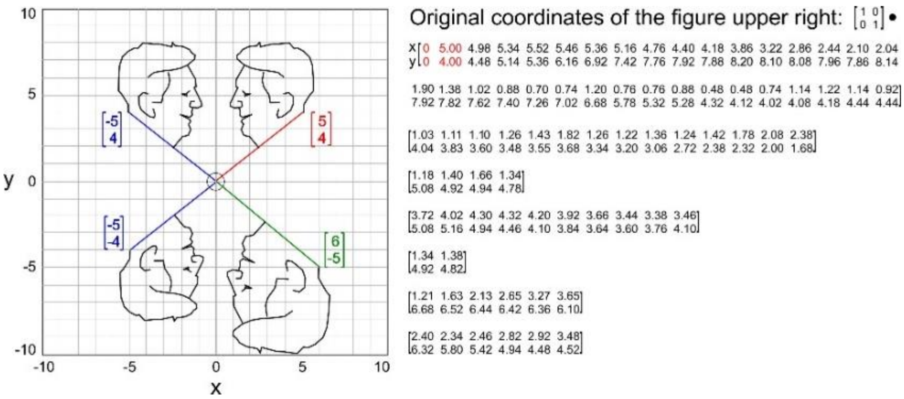


Fig. 60 Calculating Fig. 60 ***Fig. 61 Mirroring 2D, (with one slightly skewed enlargement)***

a Enlargement by a fraction is in fact a reduction, but I will call both 'enlargement'.

MATHEMATICS ABBRIVIATES THE COMMON LANGUAGE OF VERB, SUBJECT AND OBJECT

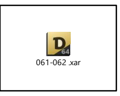
The mathematical language limits its nouns to quantities, and its verbs to operations on, or between them (+, -, *, •, ×, /, …). It has worldwide accepted conventions such as abbreviating the sentence 'object y shows a working of subject x into y'as 'y = f(x)'.

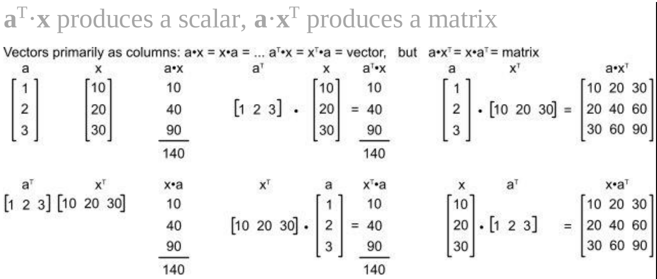
The expression f(…) is the verb, x and y are the subject and object: the working of the 'active subject' x on a 'passive object' y: y=f(x) then may be specified for example as 'squaring','x times x': 'y=f(x)=x^2'. In common language, the sequence 'I obey you' means something else than 'You obey me'. In the language of mathematics y=f(x) differs also from x=f(y). That counts for multiplying rows and columns too.

ROW•COLUMN PRODUCES A SINGLE NUMBER, BUT COLUMN•ROW PRODUCES A MATRIX

Vectors are lines with a direction, a starting point, and an end point (drawn as an arrow in ***Fig. 60***). If its starting point is supposed to be [0 0], then it is usually noted as $[x\ y]$. Vectors such as [x y] or $\begin{bmatrix}x\\y\end{bmatrix}$ are usually abbreviated into one character and written **bold** eg '**v**'; matrices such as $\begin{bmatrix}a & b\\c & d\end{bmatrix}$ are written **bold CAPITAL** eg **M**.

I write a vector **v** primarily as a *row* $[x\ y]$, its 'transposition'[a] $\mathbf{v}^T$ as a column: $\begin{bmatrix}x\\y\end{bmatrix}$.
Other mathematical conventions, however, assume the reverse: $\mathbf{v}=\begin{bmatrix}x\\y\end{bmatrix}$ and $\mathbf{v}^T$=[x y].
This has serious consequences for the meaning of $\mathbf{a}^T\bullet\mathbf{x}$ and $\mathbf{a}\bullet\mathbf{x}^T$ in both conventions:





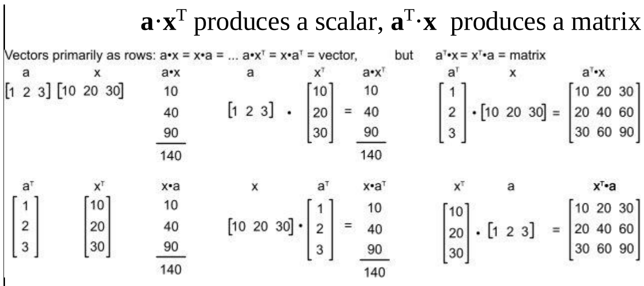


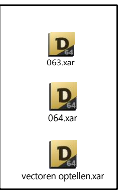
Fig. 62 Dot products not applied here:
vectors primarily as colums in Smath
[*https://en.smath.info/view/SMathStudio/summary*](https://en.smath.info/view/SMathStudio/summary)

Fig. 63 Dot products as applied here:
vectors primarily as rows in Maxima
[*https://sourceforge.net/projects/maxima/files/*](https://sourceforge.net/projects/maxima/files/)

a 'Transposition' means: 'the rows become columns, and the columns become rows'.

THREE-DIMENSIONAL SPACE REQUIRES 3 NUMBERS IN ORDER TO LOCATE A POINT

In three-dimensional space (3D) you need 3 numbers (x, y and z in ***Fig. 65***) per point. To be complete, you may note a vector as a matrix including its starting point, as it is done in ***Fig. 66***. The coloured lines of ***Fig. 65*** show the three corresponding vectors.



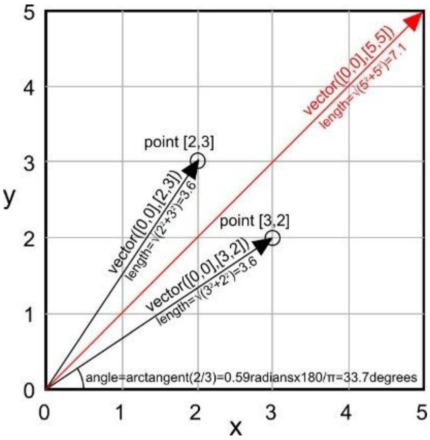


***Fig. 64** Points, vectors, their length, and angle 2D*

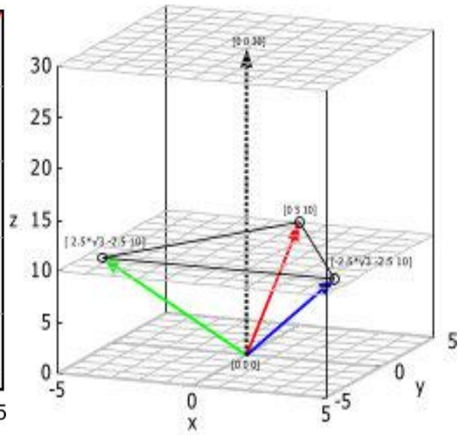


***Fig. 65** Points, vectors, and a plane 3D*

$$\begin{array}{r c} & \begin{array}{ccc} x & y & z \end{array} \\ \begin{array}{r} \text{starting point} \\ \text{end point} \end{array} & \begin{bmatrix} 0 & 0 & 0 \\ 0 & 5 & 10 \end{bmatrix} \\ \begin{array}{r} \text{starting point} \\ \text{end point} \end{array} & \begin{bmatrix} 0 & 0 & 0 \\ 2.5\sqrt{3} & -2.5 & 10 \end{bmatrix} \\ \begin{array}{r} \text{starting point} \\ \text{end point} \end{array} & \begin{bmatrix} 0 & 0 & 0 \\ -2.5\sqrt{3} & -2.5 & 10 \end{bmatrix} \end{array}$$

$$\begin{array}{ccc} x & y & z \end{array}$$
$$\begin{bmatrix} 0 & 5 & 10 \\ 2.5\sqrt{3} & -2.5 & 10 \\ -2.5\sqrt{3} & -2.5 & 10 \end{bmatrix}$$
$$\begin{bmatrix} 0 & 0 & 30 \end{bmatrix}$$

***Fig. 66** Vectors in a matrix; adding end points*

Vectors can be simply added (***Fig. 66***) into one sum vector (the dotted line in ***Fig. 65***). If the vectors represent forces, then that sum is the resulting force ('resultant').

THERE ARE DIFFERENT WAYS TO MULTIPLY *VECTORS*

Call **a**=[1 2 3] and **x**=[4 5 6], then:		Principle: call **a**=[a b c] and **x**=[x y z]:	
product **ax**:	[1 2 3][4 5 6] = [4 10 18]	**ax**:	[a b c][x y z] = [ax by cz]
dot product **a•x**:	[1 2 3]•[4 5 6] = 32	**a•x**:	[a b c]•[x y z] = ax+by+cz
'cross product' **a**×**x**:	[1 2 3]×[3 4 6] = [-3 6 -3]	**a**×**x**:	[a b c]×[x y z] = [ay-bx bz-cy cx-az]

The symbolic representation at the right side clarifies the calculation.
A normal product results in a row of separately multiplied numbers (a 'vector').
A dot product *adds* a row of multiplications into a single number (a 'scalar').
A cross product, multiplies *cross-wise* and *subtracts* a second product.
It results in a vector with important applications, explained on page 131.

Using different symbols for arbitrary numbers with a different role in the calculation ('variables'), shows the power of mathematical language.
If you 'number the numbers' in a list or vector, giving the symbol an 'index' a_1, a_2, …a_n (the separate values in **a**), then you may use even these indexes i=1,2...n in calculations such as summing ('∑').

If you name a, b as a_1, a_2 and x, y as x_1, x_2, then you can write 'sum $\mathbf{a}_i\mathbf{x}_i$ for i=1 to 2' as $\sum_{i=1}^{2} a_i x_i$. This simply means $a_1x_1+a_2x_2$, the dot product:

a•x = [a b]•[x y] = ax+by,
a•x = $[a_1\ a_2]\bullet[x_1,x_2]$ = $a_1x_1+a_2x_2$, and if $a_1=1$, $a_2=2$, $x_1=3$, $x_2=4$, then the dot product
a•x = [1 2]•[3 4] = 11.

So, these are 4 ways to write the same dot product.

MULTIPLYING *MATRICES* REQUIRES A SEQUENCE AND SOME EQUALITY IN SIZE

According to common use, a dot product **A•X** or **X•A** multiplies the *rows* of the first with the *columns* of the second (that may be confusing). So, **A•X** produces something else than **X•A.** They are 'not commutable'. This implies also, that any *row* of the first must contain as much values as the *columns* of the second, otherwise not all values of the first will get a 'partner' from the second: they are 'not-conform' (***Fig. 67***).

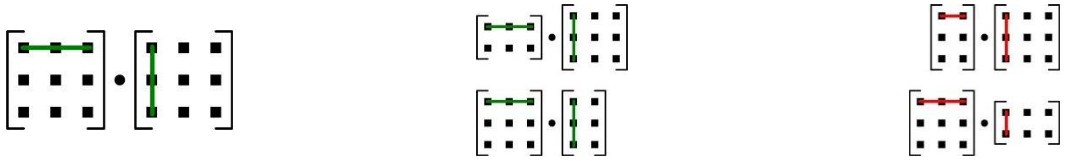
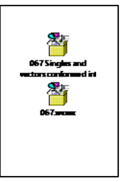


Fig. 67 Multiplying matrices

However, in order to make from a single number a vector or matrix 'conform' with the matrix you want to multiply with, you may add columns filled with zeros at the right, or rows filled with zeros at the bottom. If so, the dot product may sometimes result in a normal product, and it may even *neglect* numbers in the calculation.

Fig. 67 shows the results of a dot product you may expect from adding zeros into 2x2 matrices: normal products (here indicated by 'x', not intended as a cross product), or summed products, here indicated as x+x. The empty places are zeros (not shown).



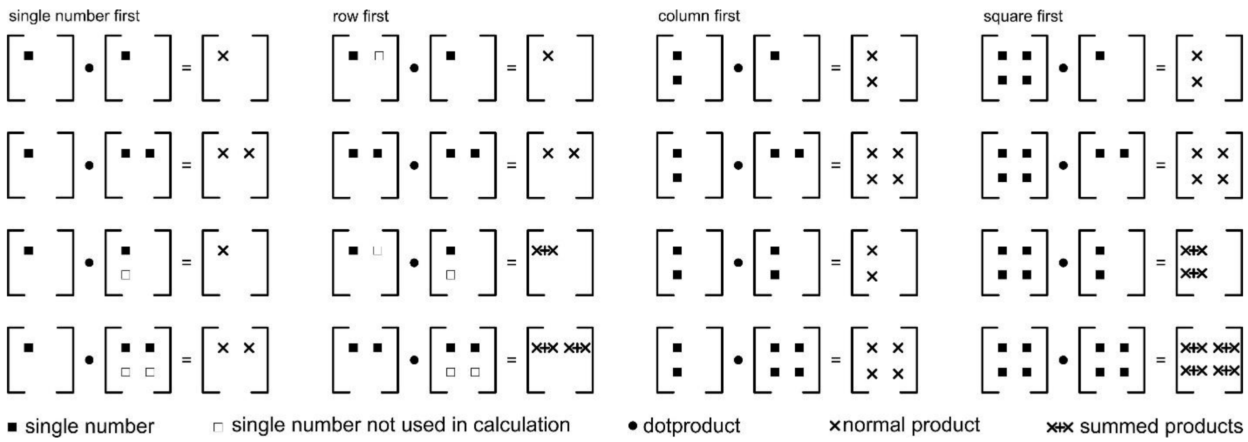


Fig. 68 Single numbers and vectors conformed into 2 x 2 matrices

The *vectors* 'row first' and 'column first' fully written out:

row first

$$\begin{bmatrix} a & b \\ 0 & 0 \end{bmatrix} \bullet \begin{bmatrix} w & 0 \\ 0 & 0 \end{bmatrix} = \begin{bmatrix} aw & 0 \\ 0 & 0 \end{bmatrix}$$

$$\begin{bmatrix} a & b \\ 0 & 0 \end{bmatrix} \bullet \begin{bmatrix} w & x \\ 0 & 0 \end{bmatrix} = \begin{bmatrix} aw & ax \\ 0 & 0 \end{bmatrix}$$

$$\begin{bmatrix} a & b \\ 0 & 0 \end{bmatrix} \bullet \begin{bmatrix} w & 0 \\ y & 0 \end{bmatrix} = \begin{bmatrix} aw + by & 0 \\ 0 & 0 \end{bmatrix}$$

$$\begin{bmatrix} a & b \\ 0 & 0 \end{bmatrix} \bullet \begin{bmatrix} w & x \\ y & z \end{bmatrix} = \begin{bmatrix} aw + by & ax + bz \\ 0 & 0 \end{bmatrix}$$

column first

$$\begin{bmatrix} a & 0 \\ c & 0 \end{bmatrix} \bullet \begin{bmatrix} w & 0 \\ 0 & 0 \end{bmatrix} = \begin{bmatrix} aw & 0 \\ cw & 0 \end{bmatrix}$$

$$\begin{bmatrix} a & 0 \\ c & 0 \end{bmatrix} \bullet \begin{bmatrix} w & x \\ 0 & 0 \end{bmatrix} = \begin{bmatrix} aw & ax \\ cw & cx \end{bmatrix}$$

$$\begin{bmatrix} a & 0 \\ c & 0 \end{bmatrix} \bullet \begin{bmatrix} w & 0 \\ y & 0 \end{bmatrix} = \begin{bmatrix} aw & 0 \\ cw & 0 \end{bmatrix}$$

$$\begin{bmatrix} a & 0 \\ c & 0 \end{bmatrix} \bullet \begin{bmatrix} w & x \\ y & z \end{bmatrix} = \begin{bmatrix} aw & ax \\ cw & cx \end{bmatrix}$$

All meet the dot product of complete 2x2 matrices fully written out:

$$\begin{bmatrix} a & b \\ c & d \end{bmatrix} \bullet \begin{bmatrix} w & x \\ y & z \end{bmatrix} = \begin{bmatrix} aw + by & ax + bz \\ cw + dy & cx + dz \end{bmatrix} \text{ BUT } \begin{bmatrix} w & x \\ y & z \end{bmatrix} \bullet \begin{bmatrix} a & b \\ c & d \end{bmatrix} = \begin{bmatrix} aw + cx & bw + dx \\ ay + cx & by + dz \end{bmatrix}!$$

VECTORS ARE GEOMETRICAL OBJECTS, MATRICES MAY TRANSFORM THEM

A cross product of two vectors: [a b c]x[x,y,z]=[bz-cy cx-az ay-bx] (supposing the origin [0 0 0] as their starting point and c=z=0), delivers the surface spanned by both.
It produces a new vector ⊥ both, with that surface as length (their 'normal').

In ***Fig. 69*** the cross product **a** x **b** produces the spanned surface 2 x 4 = 8, but it also delivers the coordinates [0 0 8] of the normal ⊥ **a** and **b**: [2 0 0]x[0 4 0]=[0 0 8]. The 'vector space' of **a** and b (captured in an xy plane) is extended into an xyz vector space.

Adding a displacement a+r: $\begin{bmatrix}0&0&0\\2&0&0\end{bmatrix}+\begin{bmatrix}5&5&5\\5&5&5\end{bmatrix}=\begin{bmatrix}5&5&5\\7&5&5\end{bmatrix}$ brings a into the first floor. The same accounts for **b**+r. ***Fig. 70*** also has halved **a** and **b**.[a] A transformation matrix $\begin{bmatrix}0.5&0\\0&0.5\end{bmatrix}\bullet$ **a** and $\begin{bmatrix}0.5&0\\0&0.5\end{bmatrix}\bullet$ **b** halved them. Simply multiplying by ½, however, has the same result.

Some matrixes multiplying a vector can be replaced by one factor ('eigenvalue').
The new vectors a and b now span a surface of 2, the length of their normal.
That is not an enlargement of ½ , but ½^2, because the new surface is ½ a times ½ b.
So, the normal is the cross product of halved a *and* b: [1 0 0]x[0 2 0]=[0 0 2].

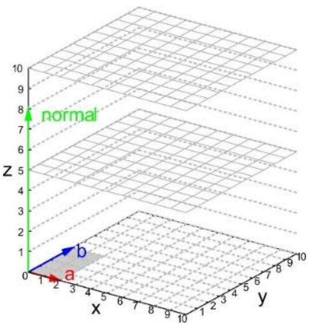


Fig. 69 The normal a x b

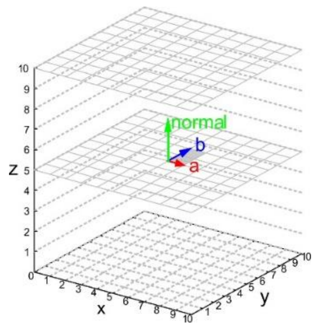


Fig. 70 Replacing and 'enlarging'[a]

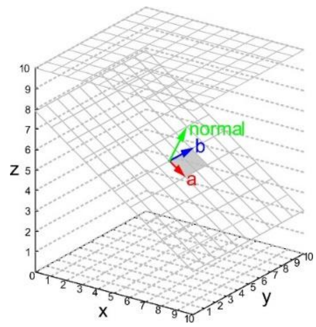


Fig. 71 Rotating

Rotating, however, requires transformation matrices without a simple eigenvalue:

Turn x

$$\begin{bmatrix}1&0&0\\0&\cos(angle)&-\sin(angle)\\0&\sin(angle)&\cos(angle)\end{bmatrix}$$

Fig. 72 ↺x-axis

Turn y

$$\begin{bmatrix}\cos(angle)&0&\sin(angle)\\0&1&0\\-\sin(angle)&0&\cos(angle)\end{bmatrix}$$

Fig. 73 ↺y-axis

Turn z

$$\begin{bmatrix}\cos(angle)&-\sin(angle)&0\\\sin(angle)&\cos(angle)&0\\0&0&1\end{bmatrix}$$

Fig. 74 ↺z-axis

$$\begin{bmatrix}0.866&0&0.5\\0&1&0\\-0.5&0&0.866\end{bmatrix}\bullet\begin{bmatrix}0&0&2\end{bmatrix}=\begin{bmatrix}1.0\\0\\1.73\end{bmatrix}\text{ first,}$$

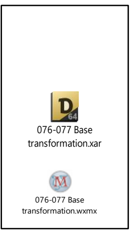
and then replaced: $\begin{bmatrix}1.0\\0\\1.73\end{bmatrix}+\begin{bmatrix}5\\5\\5\end{bmatrix}=\begin{bmatrix}6.0\\5\\6.73\end{bmatrix}$

Fig. 75 The normal in Fig. 71

Still taking [0 0 0] as a starting point, I first made the enlargement and the rotation of - 30º [b] around the y-axis in ***Fig. 71***, before adding the displacement [5 5 5]. Otherwise, the displacement itself would have been included in the enlargement and rotation as has happened in ***Fig. 59*** on page 127. ***Fig. 75*** shows this sequence for the normal.

Notice that the new plane of a and b as it has been added in ***Fig. 71***, could be seen as the xy plane of a different coordinate system. It has a different direction and it is stretched, projecting the original x units at the bottom.
That makes the x units in the new plane different from the original x units.

a Enlargement by a fraction is in fact a reduction, but I call both 'enlargement'.
b The angle 30º is 30π/180=0.5236 radians, mainly to be used as angle calculating cos(angle) and sin(angle).



THE SAME VECTOR CAN BE DESCRIBED IN DIFFERENT COORDINATE SYSTEMS

Different coordinate systems may have different directions, angles and units (***Fig 76***). The unit vectors **e** of a system contain its properties. Two coordinate systems in an xy space then have 4 unit vectors: the old units **ex**, **ey** and the new units **nex**, **ney**. Each has still an $_x$ and $_y$ coordinate in the old system: **ex**=[ex_x ex_y] and **nex**=[nex_x nex_y].

Suppose you have an arbitrary vector **v**=[0.5 0.5] in the old coordinate system (***Fig 76***). What would be the new coordinates nv_x and nv_y of *the same vector* **v** in a new system? Suppose the old *unit* vectors are **ex**=[1 0], **ey**=[0 1] (as usual), and you want to transform them into **nex**=[1 0.5], **ney**=[0.25 1]. These coordinate units contain all necessary data.

First, calculate the angles α, $\alpha+\beta$ and $\alpha+\beta+\gamma$ as arctan(nex_y/nex_x), arctan(v_y/v_x), arctan(ney_y/ney_x). That delivers the angles $\beta=(\alpha+\beta)-\alpha$ and $\gamma=(\alpha+\beta+\gamma)-(\alpha+\beta)$. Since you know the length $\|v\|=0.707$ from Pythagoras, you can calculate the length of the --- sides: $\|v\|*\sin(\beta)$ and $\|v\|*\sin(\gamma)$. ***Fig.77*** shows ***Fig 76*** in detail, using $\|v\|*\sin(\beta)$ and $\|v\|*\sin(\gamma)$, with β, γ and $\beta+\gamma$ in radians.

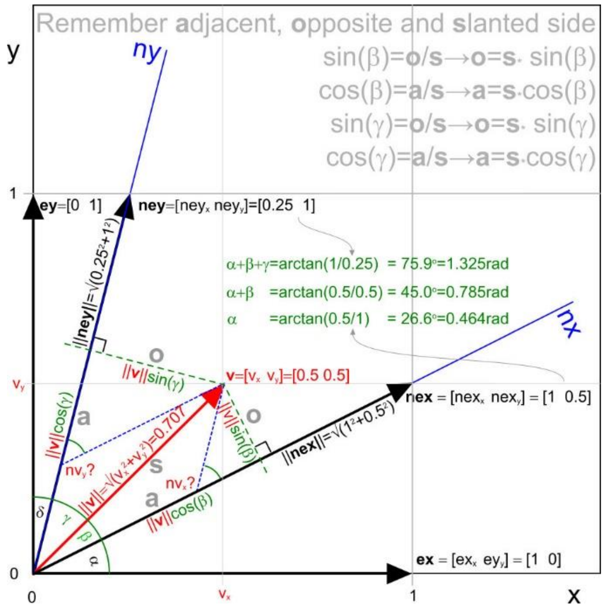


Fig. 76 A vector in 2 systems

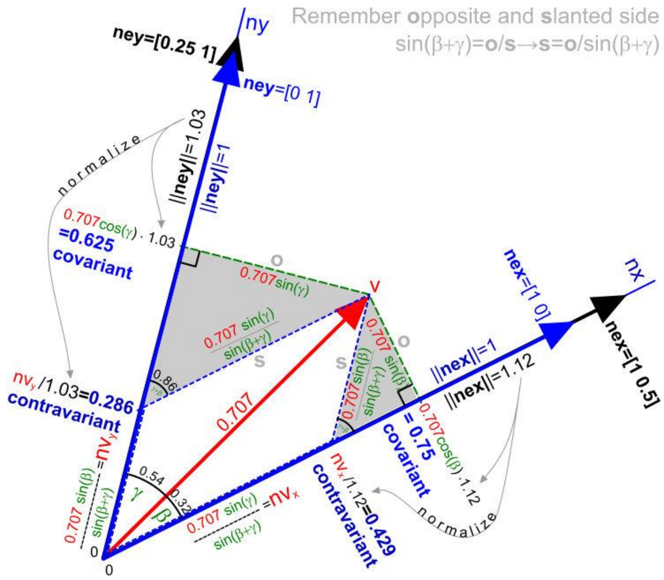


Fig. 77 Deriving new coordinates

Second, the --- coordinate lines of nv_x and nv_y (// nx and ny), create two right triangles with the same known angle $\beta+\gamma=0.86$rad, and known opposite sides $\|v\|*\sin(\beta)$, $\|v\|*\sin(\gamma)$. So, the slanted sides --- can be calculated as $\|v\|*\sin(\gamma)/\sin(\beta+\gamma)$ and $\|v\|*\sin(\beta)/\sin(\beta+\gamma)$.

Since they enclose a --- parallelogram, the // opposite sides are equal. So, they transfer these values into the new axes as the new coordinates nv_x and nv_y.

In the new system of ***Fig.77***, however, the unit vectors **nex**=[1 0.5] and **ney**=[0.25 1] become **nex**=[1 0] and **ney**=[0 1] by definition. Their lengths $\|nex\|=\sqrt{1^2+0.5^2}=1.12$ and $\|ney\|=\sqrt{0.25^2+1^2}=1.03$ should become 1 to serve as a unit. So, at last the xy values are 'normalized' by 1.12 and 1.03 into the new units, with nv=[0.429 0.286] as a final result.

A transformation matrix **P**=$\begin{bmatrix} nex_x & ney_x \\ nex_y & ney_y \end{bmatrix} = \begin{bmatrix} 1 & 0.25 \\ 0.5 & 1 \end{bmatrix}$ has an 'inverse' **Q** [a], transforming any vector directly. So: **nv**=**Q•v**=$\begin{bmatrix} 1.143 & -0.286 \\ -0.571 & 1.143 \end{bmatrix} \bullet \begin{bmatrix} 0.5 \\ 0.5 \end{bmatrix} = \begin{bmatrix} 0.429 \\ 0.286 \end{bmatrix}$ [b], and also the new unit vectors: **ne**=**Q•e**=$\begin{bmatrix} 1.143 & -0.286 \\ -0.571 & 1.143 \end{bmatrix} \bullet \begin{bmatrix} 1 & 0.25 \\ 0.5 & 1 \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$ (the 'unit matrix' with nex [1 0] ney [0 1] in columns).

Fig. 78 shows how a coordinate system with a smaller angle *reduces* the coordinates of a vector v into a smaller nv, but it *increases* nv's covariant (***Fig.77***) accordingly. That covariant is easily calculated as $\begin{bmatrix} nex_x & nex_y \\ ney_x & ney_y \end{bmatrix} \bullet$**v**$= \begin{bmatrix} 1 & 0.5 \\ 0.25 & 1 \end{bmatrix} \bullet \begin{bmatrix} 0.5 \\ 0.5 \end{bmatrix} = \begin{bmatrix} 0.75 \\ 0.625 \end{bmatrix}$ = cov (***Fig.78***). Note that **ne** = $\begin{bmatrix} nex_x & nex_y \\ ney_x & ney_y \end{bmatrix}$ writes the coordinates $_{xy}$ in *rows* instead of the *columns* of **P**.[c]

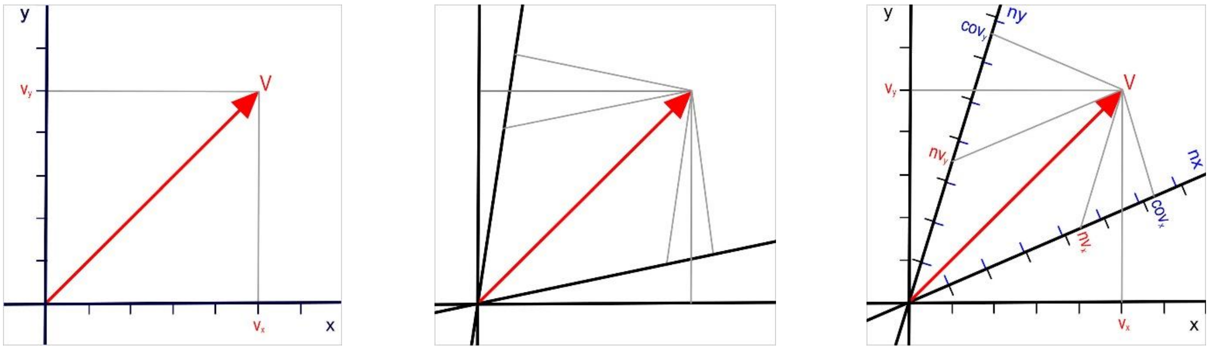
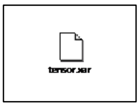


Fig. 78 In other systems than the 90º Cartesian, a covariant splits off



If you multiply **ne•P**, then you get an interesting matrix: $\begin{bmatrix} 1 & 0.5 \\ 0.25 & 1 \end{bmatrix} \bullet \begin{bmatrix} 1 & 0.25 \\ 0.5 & 1 \end{bmatrix} = \begin{bmatrix} 1.25 & 0.75 \\ 0,75 & 1.0625 \end{bmatrix} = g_{rc}$, where $_r$ means 'row' and $_c$ means 'column'. So, g_{11}= 1.25, g_{12}= 0.75, g_{21}= 0.75, g_{22}= 1.0625.
This matrix now transforms **nv** into the covariant: $\begin{bmatrix} 1.25 & 0.75 \\ 0.75 & 1.0625 \end{bmatrix} \bullet \begin{bmatrix} 0.429 \\ 0.286 \end{bmatrix} = \begin{bmatrix} 0.75 \\ 0.625 \end{bmatrix}$=cov (***Fig 78***).

The inverse of g_{rc}: $\begin{bmatrix} 1.387755 & -0.97959 \\ -0,97959 & 1.632653 \end{bmatrix} = g^{rc}$ (rc as superscript) transforms the covariant into **nv**: $\begin{bmatrix} 1.387755 & -0.97959 \\ -0,97959 & 1.632653 \end{bmatrix} \bullet \begin{bmatrix} 0.75 \\ 0.625 \end{bmatrix} = \begin{bmatrix} 0.429 \\ 0.286 \end{bmatrix}$=**nv**. Here I tacitly introduced the 'tensor-notation'[d].
If you write **nv** as v^c and its covariant as v_r, then these formula's in tensor-notation become simply: $g_{rc}v^c=v_r$ ('covariant' in ***Fig. 77***) and $g^{rc}v_r=v^c$ ('contravariant').

So, the tensor-notation omits the always intended • dotproduct sign. By that product the same indexes on different level ($_{\text{subscript}}$ and $^{\text{superscript}}$, $_{\text{covariant}}$ and $^{\text{contravariant}}$, $_c{}^c$ or $_r{}^r$) simply disappear. Even g disappears here leaving behind its remaining index ($_r$) to v.

A tensor may refer to a vector (x^c, x^r, x_c, x_r), a matrix (x^{cr}, x_{cr}), a set of matrices (x^{crm}, x_{crm}) and even sets of numbers with more 'dimensions' than 3, as Einstein needed.

If a tensor includes a covariant *and* its contravariant such as v_i^i, then it is 'invariant', independent from a coordinate system, and applicable in any coordinate system.
In ***Fig. 76*** and ***Fig. 77*** the length of vector v and anything green is invariant.
They remain equal in the old *and* in the new coordinate system.

a Professionals write the inverse **Q** of **P** as $\mathbf{P}^{-1}$. That is *not* 1/**P**=1/$\begin{bmatrix} 1 & 0.25 \\ 0.5 & 1 \end{bmatrix} = \begin{bmatrix} 1 & 4 \\ 2 & 1 \end{bmatrix}$, but $\mathbf{P}^{-1}$=**Q**=$\begin{bmatrix} ney_y & -ney_x \\ -nex_y & ney_x \end{bmatrix}$/D, where D= $nex_x ney_y - ney_x nex_y$.
D is called the 'determinant' of **P**, representing the surface of the parallelogram spanned by the involved vectors (or their volume in 3D).
b ,and the reverse v=P·nv=$\begin{bmatrix} 0.5 \\ 0.5 \end{bmatrix}$. Note that the coordinates of a vector now have been written in a column $\begin{bmatrix} x \\ y \end{bmatrix}$.
c **P** has apparently been a 'transpose' of **ne**. You may write that as **P**=$\mathbf{ne}^T$.
d Invented by Ricci;Levi-Civita(1899)Méthodes de calcul différentiel absolu et leurs applications(Leibzig1901)Teubner

VECTORS CAN BE DESCRIBED WITHOUT AN EXTERNAL COORDINATE SYSTEM

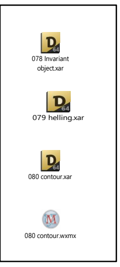
In any description of the same vectors, their lengths and mutual angles should remain equal ('invariant'), no matter how you may change the coordinate system.
Tensors offer means to change the coordinate system (previous page).

Classical geometry did not even even *require* an external coordinate system in order to arrive at valid geometric conclusions and proofs, such as the Pythagorean theorem. Just as the instructions of a navigator in your car, lengths and mutual angles are sufficient for an object description (***Fig. 79***).

Starting with a vector you can describe an object with *lengths and angles* alone. From a vector **v** continue as route: 'turn 56° to the right, drive 72m, turn 23° to the left, drive 49m ...' and so on.

An angle can be expressed as a partial length ratio Δy/Δx (slope). Then, in the common tangent *point* with a curve, their 3/4 proportion (dy/dx) remains. You can draw it as a '*slope vector*'.

For a 3D curved surface you can draw a 2D 'vector field' of such slope vectors at any point as a 'gradient', a set of 'derivatives'. Derivatives (the slope vectors) are explained in § 26 p136.



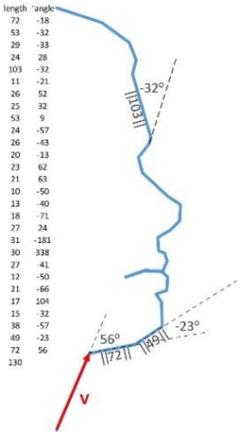


Fig. 79 Invariant object description

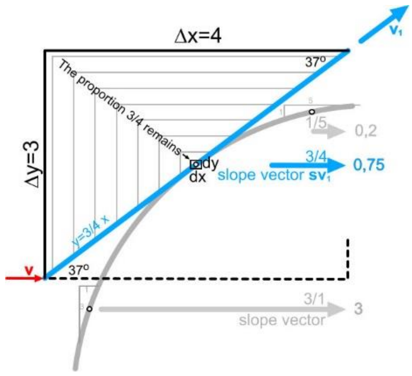


Fig. 80 Derivatives as slope vectors

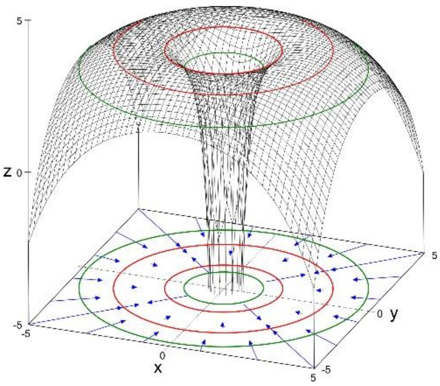


Fig. 81 3D Derivatives: a 2D vector field

In ***Fig. 80*** a new 37° angle is defined by two ⊥ partial lengths Δx=4 and Δy=3 as its slope Δy/Δx=3/4. This *proportion* (the *tangent*) remains equal, no matter how far you reduce Δx and Δy equally, even making them indivisibly small (dy/dx). This proportion itself (derivative) can be drawn as a 'slope vector' $\mathbf{sv_1}$ with a length $\|\mathbf{sv_1}\|$.

A curve may have different slope vectors at any point (with one point 'tangent' to $\mathbf{v}_1$).
In ***Fig. 81*** a 2D 'vector field' of slope vectors at the bottom is drawn from a 3D object. That vector field describes the slope of its surface in x and y direction as its derivative.

These operations, however, do not produce *transformations* as made by linear algebra. They only demonstrate, that length and mutual angles of vectors can be invariant.
In order to disengage from a presupposed external coordinate system, in linear algebra you need 'tensors' *including* arbitrary coordinates *and* their unit vectors, changing the reverse (if the unit halves, then the coordinate doubles).

§ 26 CALCULUS MAKES INFINITELY SMALL QUANTITIES COUNTABLE

The growth of a population, the compound interest of your capital or the length of your child[a] can be measured per year, per quarter, per month and so on.
Fig. 82[b] shows two examples (red and green) of growth with a different growth rate. The vertical axis (y) shows people, euro's, centimetres or whichever other quantity.

The growth rate is shown by right triangles of different size and precision.
The proportion of the rectangular sides is a measure for the local direction of the curve. The opposite/adjacent side of their growing angle is called the 'tangent'.

The slanted side of the largest triangle is the diagonal, where y=x in any point.
You may calculate the growth rate in 10 years as the slope of the diagonal as y/x=1 in any point, eg (6,6) y/x=6/6=1.[c]
Fig. 82 shows your overestimation compared to the 'real' (slowly increasing) growth.

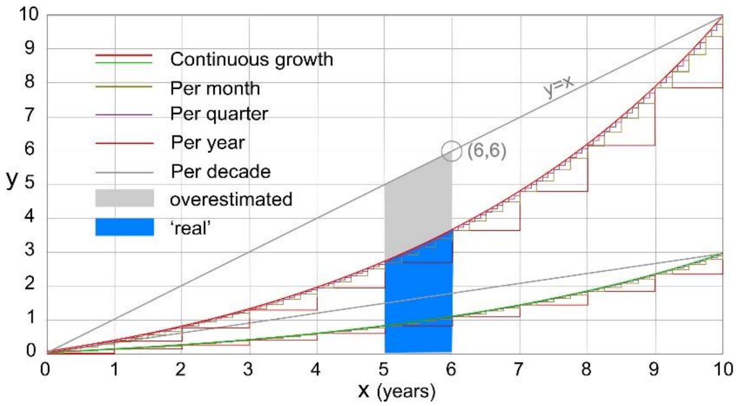


Fig. 82 Growth or increase measured per period of time[d]

Even if the *size* of a triangle approaches zero, then its *direction* is still calculable. Calculus is invented in order to calculate it in indivisibly small triangles on a curve (**differentiation**), and to sum multiplications by infinitely small 'sizes' (**integration**).

A quantity **x** or **y** (eg a distance) approaching zero is commonly represented as '**dx**' or '**dy**' (Leibniz did that for the first time in 1684). Then, their quotient (proportion, tangent, and thus the slope in a point) is $\frac{dy}{dx}$ ('differential quotient' or 'derivative').
In a curved line (for example $y=x^2$), the slope differs in each point. If $y=x^2$, then you can write its derivative as $\frac{d}{dx}x^2$. The invented rule was: it has a non-zero *value*: $\frac{d}{dx}x^2 = 2x$.

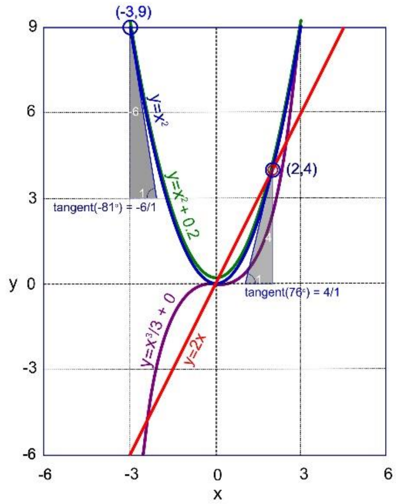
Integrating (∫) is summing; $\int_5^6 y\,dx$ is the sum of the 'surfaces' of all indivisibly thin lines $y{*}dx$ from (x=) 5 to 6 (the surface in ***Fig. 82***). It has a non-zero *value* too.
Calculating this 'definite integral' of $y{*}dx$ from 5 to 6 delivers a surface 5.5.
Fig. 82 shows that immediately, but you need calculus if the limiting lines are curved.
An integral ∫ *without* boundaries such as 5 and 6 is noted as $\int x^2 dx$. Let's draw it.

a https://www.vub.be/groeicurven/groeicurven.html
b These figures and many of the following are made in MSExcel.
c 1=100% in terms of traffic roads. A 100% steep slope means 45^0 upwards. In *Fig. 81*, however, x and y do not have the same unit lengths..
d https://commons.wikimedia.org/wiki/File:Compound_Interest_with_Varying_Frequencies.svg shows the original drawing of Jelson25, edited here.

DIFFERENTIATING AND INTEGRATING SUPPOSE INDIVISIBLE SMALL QUANTITIES

You can draw $y=x^2$ as a parabola (***Fig. 83***). Its derivative[a] $y' = \frac{d}{dx}x^2 = 2x$ is a straight line. It represents the slope (– is down, + is up) in any point of the parabola.
The 'integral' $\int 2x\,dx$ transforms $2x$ back to a *set* of parabolas $y=x^2+c$.
The original $y=x^2$ (where c=0) is one of them.

Integrating keeps an uncertainty c (a constant) about the precise location.
In ***Fig. 83*** I have drawn $y = x^2 + 0.2$ with a little shift of 0.2 upwards, in order to distinguish that integral visually from the original $y=x^2$.



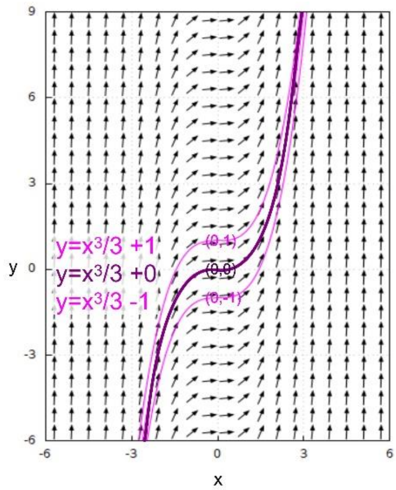


Fig. 83 Differentiating and integrating ***Fig. 84 Vector field of $y=x^3/3+c$***

An 'Ordinary Differential Equation'(ODE), eg $\frac{dy}{dx} = x^2$, has an 'explicit solution': $y=2x$.
The 'implicit solution' solves ^{y} *in* the ODE itself by *integrating* x^2: $y = \int x^2\,dx = \frac{x^3}{3} + c$, a *set* of solutions. It is a set, because from the known *directions* only, you may derive more solutions (***Fig.*** 84). ***Fig. 83*** shows the one where c=0. So, distinguish:

the original formula	eg $y=x^2$
its 'simplifying' explicit ***derivative***	eg $\frac{d}{dx}x^2 = 2x$
a reverse 'complicating' ***integral***	eg $\int 2x\,dx = x^2+c$
a ***differential equation (ODE)***	eg $\frac{dy}{dx}=x^2$
and its ***implicit solutions*** for the implicit y	eg $\frac{x^3}{3} + c.$

Differential equations have become crucial tools in science and technology. Solving them, deriving an explicit y' from a derivative, an implicit y from directions only, and solving an integration in general, requires specific rules in different cases. I will use them without explaining. Inventing such rules has been a main challenge since Newton and Leibniz opened up this field of mathematics ('calculus') around 1700AD. Many (more complicated) ODE's, however, still cannot be solved algebraically.

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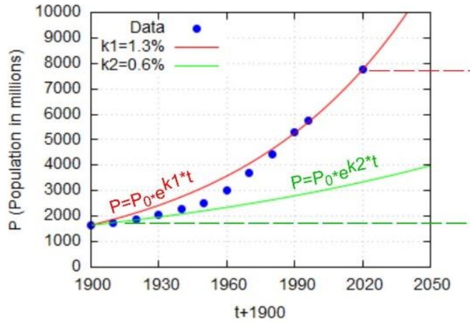
a A derivative of y (e.g. $y=x^2$) is often coded with an apostroph as y' (eg $y'=\frac{d}{dx}x^2$).

CALCULATING EXPONENTIAL GROWTH REQUIRES CALCULUS

If you want to estimate the world population of 2050, then you should use historical data (***Fig. 85***). The population of 1650million in 1900 (P_{1900}) became 1750million in 1910 (P_{1910}). That is 6% growth 'k' in a decade. You may suppose that a population P_0 will grow with a growth factor k in a time period t: $P(t)= P_{1900}*k*t$.

From this experience ($P(1910) = 1650+1650*0.06*1=1750$million), your preliminary model becomes $P(t)=P_0+P_0*k*t$, where P_0 is the initial population in millions and t the time period in decades. Your preliminary model predicts a population $P(2050) = 1650 + 1650*0.06*15 = 3135$ million in 2050. The world population of 7750 in 2020, however, is already much larger then your 3135 million. What's wrong?



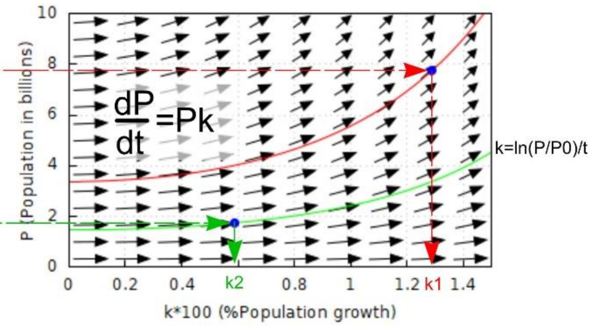


Fig. 85 Population data and models ***Fig. 86 Their changing growth factor***

The data until now (***Fig. 85***) show that the *growth rate k itself increases* (***Fig. 86***). Moreover, it does not increase every decade, but every second or even every indivisible moment 'dt'. In order to model that, you need calculus. Then[a], the *change* of the population dP per moment dt, $\frac{dP}{dt} = Pk$, that is a *set* of directions (***Fig. 86***) of P(k).

One known point indicates the curve. Solving $\frac{dP}{dt} = Pk$ produces $P=P_0e^{kt}$, where $k=\ln(P_1/P_0)/t$.[b]
If $P_0=P_{1900}=1650$, $P_1=P_{2020}=7750$, and $t=2020-1900=120$, then $k=\ln(7750/1650)/120=0.013$ (1.3%).
Once knowing k, you can calculate any population such as those in 2050 and 1990:
$P_{2050}(= P_0e^{k*t})=1650*e^{0.013*120}= 11\,597$, and $P_{1990}(= P_0e^{k1*t})=1650*e^{0.013*90} = 5\,316$ million people.
That fits well with the known population of 2020 and 1990 in ***Fig. 85***.

But what about 'e' and 'ln'?

You may be used to logarithms based on 10: $\log(1)=0$, $\log(10)=1$, $\log(100)=2$, and so on.
Calculus, however, uses the 'natural logarithm' $\ln(x)$ based on $e= 2.718281828459045$ ('Euler's number'), where $\ln(1)=0$, $\ln(2)= 0.693$, $\ln(e)=1$, and $\ln(3)= 1.099$.
The advantage using this 'e' as a base of logarithms is easy differentiating and integrating expressions with e^x. Its derivative and integral both *equal* e^x!

Fig 86 shows that eg e^3, its derivative, and its integral produce all the same value 20.
A little difference, eg $(e+0.2)^3$ and $(e-0.2)^3$ instead of e^3 causes *different* outcomes.
The base 10 produces no equality at all, and because of that, complicated calculations.

a Steward(1998)Calculus Concepts and Contexts(Pacific Grove)Cole Publishing Company p527-531
b Steward(1998)p529,where e is Euler's number or Napier's constant, the base of the natural logarithm ln(x), to be explained soon.

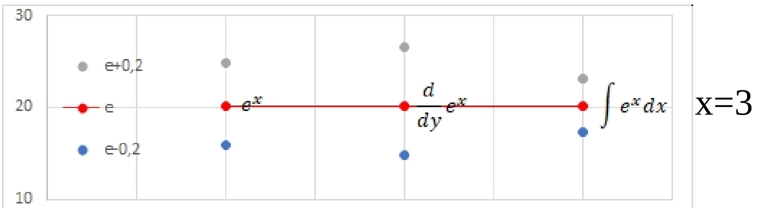


Fig. 87 Small differences of e already produce different differentials and integrals

Napier discovered the 'right middle' around 1600. Euler called it 'e' and described its amazing properties for calculus and trigonometry around 1730 in detail.[a]
That is why it is finally called 'Euler's number'.

AN OTHER TIME SCALE MAY REQUIRE A DIFFERENT FORMULA

The world population on the very long term (***Fig. 88***) frightens me.
Fig. 89 exaggerates the lower values by log10 in more detail. It shows more clearly the reductions after 5000BC and year 0 we perhaps may face also in our future.
The growth is due to human technology, the decline to disasters of different kind.

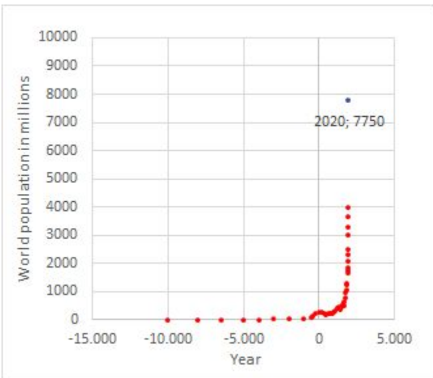


Fig. 88 World population in 20 000 years[b]

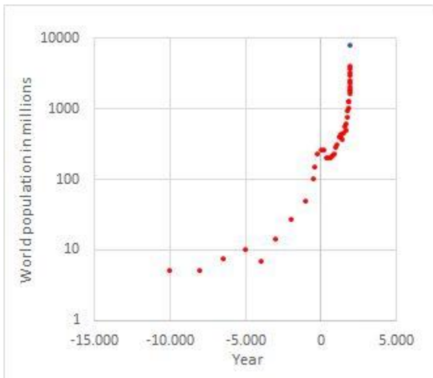


Fig. 89 Fig 88 on a logarithmic scale

Fig 90 gives a closer look on the last century: a growth of P, doubling in 40 years.

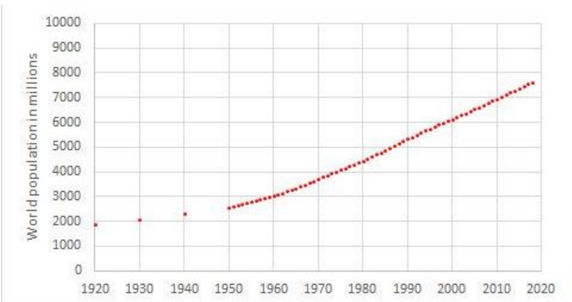


Fig. 90 World population P in a century[c]

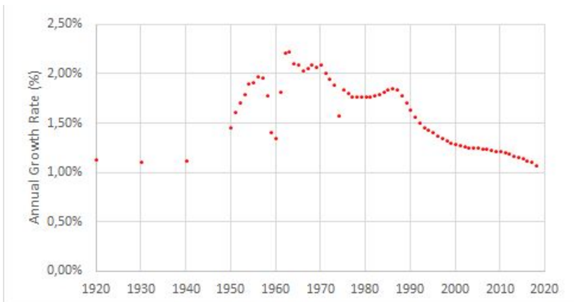


Fig. 91 Growth rates k per year

Fig 91, however, shows declining growth *rates* k per year after 1960.
That should have a flattening effect on the world population after some generations.
Moreover, the carrying capacity of the Earth sets its limits.

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a Euler(1728) Meditatio in Experimenta explosione tormentorum nuperinstituta, translated in English: Smith(1929)A source book in mathematics(New York)McGraw Hill p95
b Average of different sources from https://nl.wikipedia.org/wiki/Wereldbevolking .
c From 1975: https://www.worldometers.info/world-population/world-population-by-year/ up to 1975: https://web.archive.org/web/20150426165332/http:/www.census.gov/population/international/data/worldpop/table_population.php . The estimates, of *Fig 90* show declining growth *rates* per year after 1960. That should have a flattening effect on the world population after some generations.

Malthus(1798)[a] predicted famine disasters, based on exponential growth ($\frac{dP}{dt} = Pk$, solved as $P{=}P_0e^{kt}$ in ***Fig. 85*** on page 137). Verhulst(1845) included a carrying capacity as K in his 'logistic equation': $\frac{d}{dt}P = P(1-\frac{P}{K})k$, solved as $P = \frac{K}{1-e^{-ck}e^{-kt}}$, where $k{=}k_{max}$.
If $k{=}k_{max}$ and c are constants, then $-e^{-ck}$ is a constant. Replacing it by 'A', you can write $P(t) = \frac{K}{1+Ae^{-kt}}$. Solving A for an initial population P_0, delivers $A= (K-P_0)/P_0$.[b]

Fig. 92 draws $P(t) = \frac{K}{1+Ae^{-kt}}$, where $A{=}(10\text{-}2)/2{=}4$, the carrying capacity is assumed to be $K{=}10$ (billion people), and k should be $k{=}0.025{=}2.5\%$. The point 1920 from ***Fig. 90*** chooses the curve in ***Fig. 93***, and 2020 from the same source fits nicely in ***Fig. 92***.

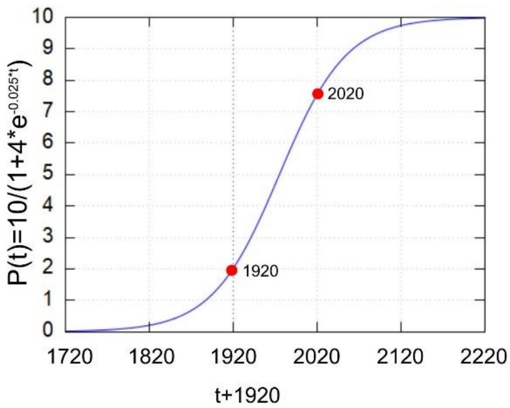


Fig. 92 A logistic Model 1720-2220

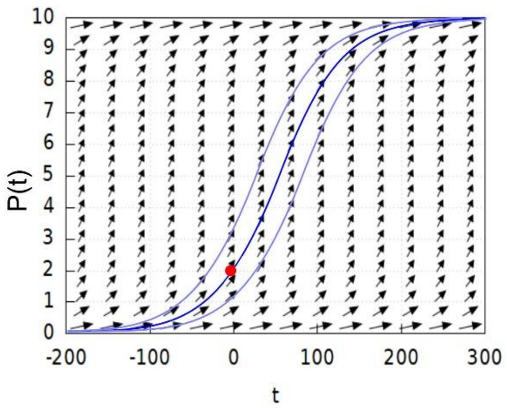


Fig. 93 Vector field of $\boldsymbol{\frac{d}{dt}P = P(1-\frac{P}{K})k}$

Fig. 92 predicts, that the world population should be stable in 2220.
The growth rate in ***Fig. 91*** then should continue to decline in order to reach 0% at last.

There are, however, more processes with effect on the changing world population than birth and mortality. ***Fig. 91*** shows a dip in the growth rate around 1960, probably due to world wide pessimistic expectations during the Cold War and the new availability of birth control agents. Their effects are difficult to predict.

The dips in ***Fig. 89*** after 5000BC and the year 0, however, are probably due to epidemics or famine. Such disasters, may be simulated by predator-prey models.

PREDATOR-PREY MODELS FLUCTUATE APPROACHING THE CARRYING CAPACITY K

The growth and decline of preys followed by those of predators eating them, depends on at least 6 supposed values ('parameters'), resulting in very different predictions, eg:

Initial number of preys:	$preys_1$=	8	Initial number of predators:	$predators_1$=	2
Growth rate preys without predators:	Gpreys=	0.2	Growth rate predators feeding on prey	Gpreds=	0.029
Death rate preys by predators:	Dpreys=	0.1	Death or emigration rate predators:	Dpreds=	0.2

The 'Lotke-Volterra model'[c] (***Fig. 94***), with these parameters, predicts for time t:

the next population	=the previous population	+the same, times	(their growth rate	minus their decline):
$preys_t$	$=preys_{t-1}$	$+(preys_{t-1}$	$*(Gpreys$	$-Dpreys*predators_{t-1})$
$predators_t$	$=predators_{t-1}$	$+(predators_{t-1}$	$*(Gpreds*preys_{t-1}$	-Dpreds).

a Malthus(1798)An essay on the principle of population()
b Steward(1998)Calculus Concepts and Contexts(Pacific Grove)Cole Publishing Company p540-541 shows this derivation in more detail.
c Volterra, V., 1926. Fluctuations in the abundance of a species considered mathematically. Nature 118: 558 – 560.

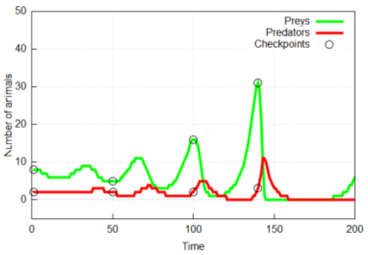


Fig. 94 Survival (Gpreds=0.029)

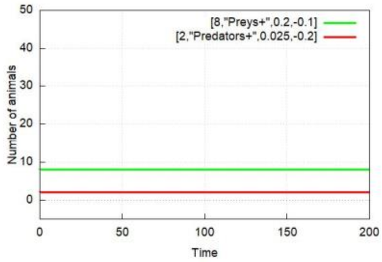


Fig. 95 Equilibrium (Gpreds=0.025)

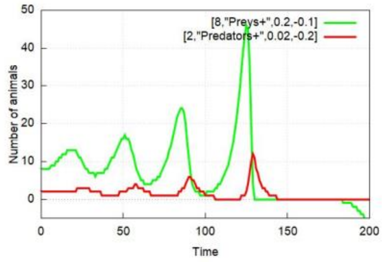


Fig. 96 Extinction (Gpreds=0.020)

Small changes of one parameter already may have great effect. If you *decrease* the growth rate (fertility) of the predators in ***Fig. 94*** from Gpreds=0.029 to 0.020, then both animal species die out at last. ***Fig. 96*** shows near zero numbers (rounding the remaining positive fractions), and after t=150 at last even imaginary negative numbers of prey, a clear message of extinction. At Gpreds=0.025 in ***Fig. 95***, both seem stable.

You would expect that a lower fertility of the enemies increases the chance of survival of the victims. The counter-intuitive result of ***Fig. 94 - Fig. 96*** shows a great utility of mathematical models. The sensitivity of their parameters may make their outcome uncertain, but it prevents premature false suppositions.

A prudent comparison with the human world population of ***Fig. 88*** may interprete epidemics, famine and other disasters as our predators. Our very successful technological fight against them may decrease their growth rate, but that does not exclude extinction after excessive growth by a furious come-back of predators.

The second part of Volterra's formula decribes the *change* of preys and predators in its change-terms[a] as $\Delta P/\Delta t = \text{preys}*(\text{Gpreys}-\text{Dpreys}*\text{predators}_{t-1})$, and $\text{predators}*(\text{Gpreds}*\text{preys}_{t-1}-\text{Dpreds})$. If they do *not* change (both 0), then (if preys and predators are not 0) the terms between the brackets produce a 0. That is the case if $\text{preys}=\frac{\text{Dpreds}}{\text{Gpreds}}$ and $\text{predators}=\frac{\text{Gpreys}}{\text{Dpreys}}$.

In that case preys and predators keep eachother in balance (equilibrium, ***Fig. 95***) with indeed everywhere 0.2/0.1= 2 predators and 0.2/0.025= 8 preys.

Fig. 95 suggests no change at all, but in reality predators cannot survive without eating preys, simultaneously changing their number. They should *fluctuate* around (8,2). Plotted against the time this results in a regular (but not exact sinus-like) fluctuation of preys and predators *around* (8,2). Let us take Gpreds=0.029 of ***Fig. 94***.

a Instead of dy/dt, because the supposed time periods are not near zero (dt). Δ indicates a certain distance between 2 points or moments.

Gpreys=0.2, Dpreys=0.1, Gpreds=**0.029**,Dpreds=0.2

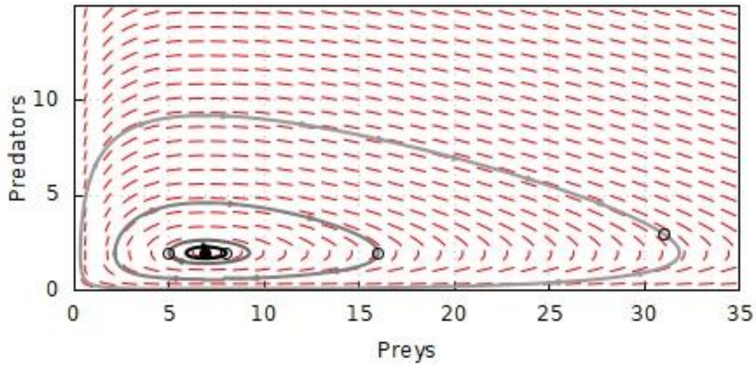


Fig. 97 Vector field with solutions○ in (5,2), (16,2), (31,3) around the equilibrium ● (7, 2)

The dy/dt vector field (***Fig. 97***) resembles the one you could draw for ***Fig. 94***, but the equilibrium point shifts to 0.2/0.029=6.897 preys (point ● (6.897,2) in ***Fig. 97***).
It makes many cycles possible depending on the number of animals you may observe any time in reality ('initial points'○) such as (16,2) or (31,3).
Fig. 97 shows the cycles you might expect at these 'checkpoints'o of ***Fig. 94***.

If 2 foxes eat 3 of 8 rabbits, then there are 5 rabbits left, so you should draw point (5,2) in ***Fig. 97***. Through that point you can draw a counter clockwise cycle: one fox will die if only 5 rabbits are left.

The number of rabbits harrased by only 1 fox now increases to 7: (7,1). That is again enough for 2 foxes, while the number of rabbits will still increase further to (9,2). That is enough for 3 foxes bringing the number of rabbits back to 7, point (7,3). Then 1 fox dies by lack of food. The cycle reaches its initial point (5,2), and starts anew.

A few questions arise. What means 6.897 preys? A part of a prey is no prey. Calculus counts with fractions of preys, not their natural whole ('integer') numbers. The graphs may remain valid if you read the population numbers as thousands, but even then the remaing fractions should be interpreted as gaps in the continuous line.

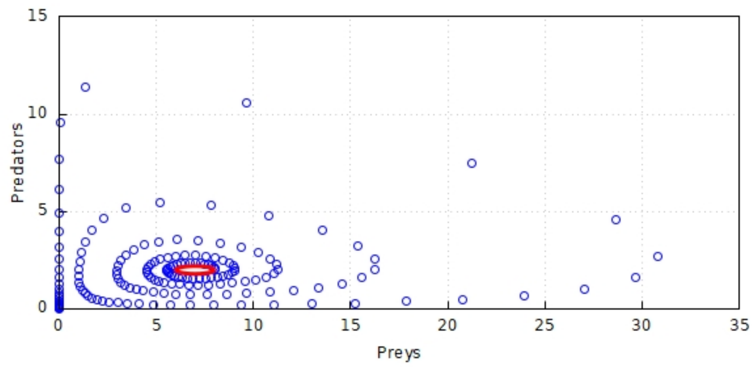


Fig. 98 Jumping in the vector field of Fig. 97. A final extinction of both species at (0,0)

An equilibrium? A regular cycle? ***Fig. 94*** shows something else.
The *changing* change-terms are added to the previous population (t-1).
If that itself changes too, then ***Fig. 97*** should be a curve jumping every time interval (Δt) into another cycle, resulting in a spiral (***Fig. 98***) with gaps Δt=1

instead of dt→0. In ***Fig. 98***, the values are not continuous as it is supposed in ***Fig. 97***: a closed succession of indivisible moments dt.

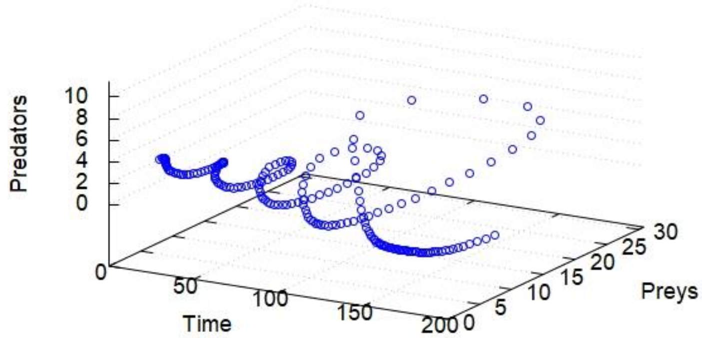


Fig. 99 The relation of the numbers of Preys and Predators (Fig. 98) extruded in time

If you draw a 3D graph involving time ⊥ to the plane of ***Fig. 98***, then you get ***Fig. 99***. Project the curve on the floor (the Preys-Time plane), and you will see the prey curve of ***Fig. 94***. Project it on the front wall (the Predator-Time plane), and you will see the predator curve of ***Fig. 94***.

Looking at the backwall from the preys to the predators you will see ***Fig. 98***.
The points, however, still do not represent individuals, but moments in time with imaginary fractions of animals.

You may meet the boundaries of applying calculus in ***Fig. 94-Fig.100***.
The curves are not continuous. Even ***Fig. 94-Fig.98*** are connected separate (discrete) numbers (calculated 'nummerically'), based on time intervals (Δt).

The basic philosophy of calculus is to minimize Δt into its 'limit' dt = Δt→0, but that kind of minimization does have a strange effect on the shown graphs, originally based on Δt=1. In ***Fig. 100*** that is minimized to Δt=0.1.

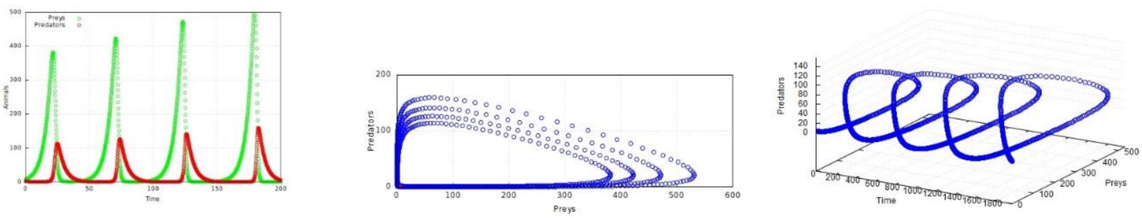


Fig. 100 The graphs of Fig. 94, 98 and 99 drawn with Δt=0.1

The effect of taking a smaller Δt than 1 (0.1) is not only a 10 times multiplication of numbers, but also a more regular pattern. Further minimization would result in infinitely many numbers, theoretically approaching only one repeated cycle somewhere outside the boundaries of ***Fig. 97***.

'Euler's method'[a] clarifies what happened.

[a] Euler(1768)Institutionem calculi integralis(Petrolopi)Impensis Academiae Imperialis Scientiarum, Book 1, part 1, section 2, chapter VII, page 424 in the edition Engel Schlesinger(1913)

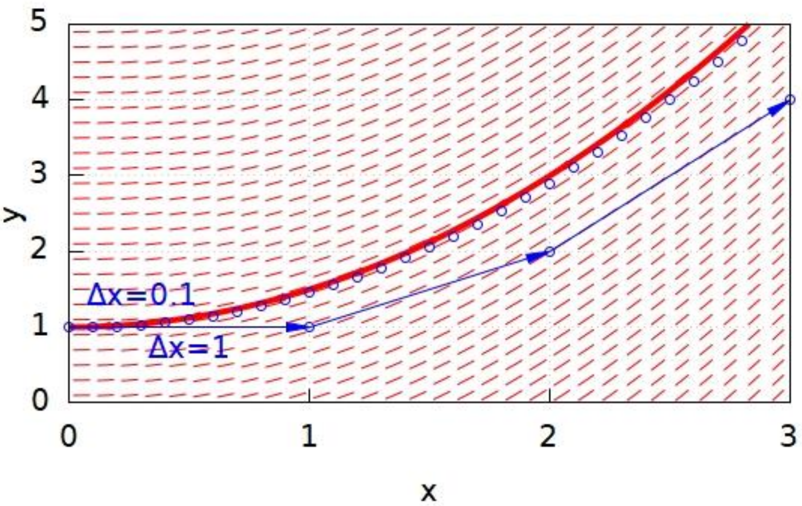


Fig. 101 Euler approximation of a parabola at Δx=0.5 and Δx=0.05

EULER'S METHOD

Some ODE's cannot be solved into an algebraic formula. Euler invented a numerical method in order to calculate an approximate solution.

He took discrete points at a distance Δx of each other and added the changes (the slopes, the derivatives) valid at each point itself.

Euler's approximation neglects the changes of direction in between two points separated by Δx, where the calculus solution sums *all* changes dx at any x.
He takes the slope of the first point as if it will not change until the second point.
The direction field of ***Fig. 101*** shows clearly that it also changes in between.

In this case y in the ODE $\frac{d}{dx}y = x$ can be solved also algebraically as $y = \frac{x^2}{2} + c$.
Fig. 101 shows how you can approach this final solution by minimizing Δx.
If dx or dy cannot be concerned as infinitely small, but restricted to a quantum such as preys, predators or the smallest indivisible discrete amount of matter, energy or movement in quantum physics, then differential calculus fails.

In that case, the ideal result of a differential equation may differ very little from the real change, but even immeasurably little differences can be enlarged to measurable differences in iterative processes (§ 28 p150).

These exercises show that calculus can be used for variables with contiguous values.
It is particularly useful if these do not result in straight, but in curved lines.
This implies the important possibility to calculate surfaces between curved borders.
On page 191 I will explain this part of calculus in the context of thermodynamics.

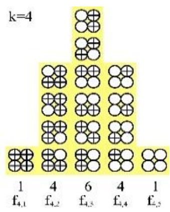
§ 27 PROBABILITY REDUCES DIFFERENCES INTO DEVIATIONS

BINOMIAL CHANCE DETERMINES HOW OFTEN YOU CAN EXPECT A YES OR NO

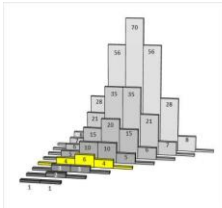
With the throw of a coin, cross ⊕ or coin ○ both have the same (binomial) chance ('probability') p = ½ (50%). After throwing twice (k=2) there are 4 possibilities (N=4): ⊕⊕, ⊕○, ○⊕ or ○○ with each ¼ (25%) chance p. After three times (k=3) you have made one of N=8 combinations: ⊕⊕⊕, ⊕⊕○, ⊕○⊕, ○⊕⊕, ⊕○○, ○⊕○, ○○⊕ or ○○○. With four throws (k=4) there are $N=16=2^4$ possibilities. In short: $N=2^k$ possibilities for k throws.

Throwing 4 times (or 4 coins at the same time) you rarely throw ⊕⊕⊕⊕ or ○○○○ and most often ⊕⊕○○ (in different sequences). There is only 1 possibility to throw ⊕⊕⊕⊕, 4 to throw ⊕⊕⊕○, 6 to throw ⊕⊕○○, and so on (***Fig. 102***). In short, the 'frequency' f = {1, 4, 6, 4, 1}. Their 'probability' p is f divided by the number of all possibilities N: p = f/N = {1/16, 4/16, 6/16, 4/16 and 1/16}. The biggest probability p (to throw ⊕⊕○○) is p=f/N=6/16=38%.

With more throws or coins, the writing out of all combinations N and sorting on frequencies f becomes laborious.



k	f		$\sum f_k = N$	
1	f_1	1 • 1		=
2	f_2	1 • 2 • 1	2^2	4
3	f_3	1 • 3 • 3 • 1	2^3	8
4	f_4	1 4 6 4 1	2^4	16
5	f_5	1 5 10 + 10 5 1	2^5	32
6	f_6	1 6 15 20 15 6 1	2^6	64
7	f_7	1 7 21 35 35 21 7 1	2^7	128
8	f_8	1 8 28 56 70 56 28 8 1	2^8	256



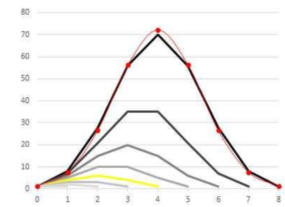
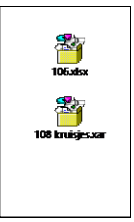
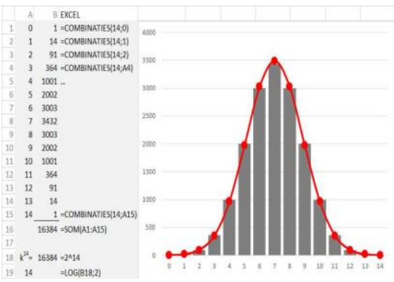


Fig. 102 frequencies ***Fig. 103 Triangle of Pascal*** ***Fig. 104 The frequencies …*** ***Fig. 105 … roughly a clock shape***

Pascal invented a triangle of numbers to predict the frequencies of each subsequent throw k, by adding two higher numbers each time (***Fig. 103***: for example 10 + 10 = 20). The sum of each row $N= \sum f_k = 2^k$. In row f_8 (k = 8 throws) there are already $N = 2^8 = 256$ possibilities in 9 frequencies.

Fig. 104 shows all frequencies in a bar graph. ***Fig. 105*** also suggests intermediate values, but the 'binomial distribution' itself is 'discrete', not 'continuous'.





$$\binom{k}{k_x} = \frac{k!}{k_x!\,(k-k_x)!}$$

1 over 4 2 over 4 3 over 4

$\frac{4*3*2*1}{1*3*2*1}$ $\frac{4*3*2*1}{2*1*2*1}$ $\frac{4*3*2*1}{3*2*1*1}$

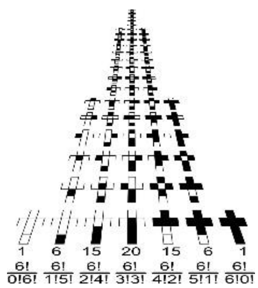


Fig. 106 Galton-board[a] ***Fig. 107 2^{14} = 16384 combinations divided over 15 columns*** ***Fig. 108 Binomium of Newton: k_x over k combinations*** ***Fig. 109 2^6 combinations***

Galton came up with a plate with rows of nails that resembles the Pascal triangle (***Fig. 106***). Bullets that fall in the middle of the top nail can go in two directions. They fall

a https://yourstory.com/2016/08/02373fb268-power-of-thoughts-truth-or-bullshit/

in the next row on a nail where they also can go two ways and so on (binomial).
After $k = 14$ rows, a bullet has covered one of the $N = 2^{14} = 16384$ possible paths. It is then captured in one of the $k+1=15$ frequency columns (including column 0: $f_0, f_1, f_2 \ldots f_{14}$).

There is only one path to end up in one of the two outer ones. The probability ending up there is 1 of 16384 (0.006%). The other possibilities are calculated in ***Fig. 107***.
Newton came up with the formula, his 'binomium' (***Fig. 108***). The symbol '!' is called 'faculty': $0!$ and $1!$ are both 1, but $2!=2*1$, $3!=3*2*1$, $4!=4*3*2*1$, and so on.
The probability of ending up in the middle column (f_7) is thus the frequency 7 out of 14 (= 3432) from a total of N=16384 (21%).

An urban site in ✠ form with 6 lots (***Fig. 109***), of which 0, 1, 2, 3, 4, 5 or 6 can be built, has in that order f = {1, 6, 15, 20, 15, 6 or 1} (total N = 64) building possibilities.
There are surprisingly many other cases where a combination must be chosen from an unbeatable number of possibilities ('combinatorics').

Compiling a team from a football club with 25 members has 11 out of 25 = 4 457 400 possibilities ('combinatorial explosion'). The coach therefore has a considerable choice problem. If he left it to chance, the possible outcomes would amount equal to throwing 11 dice with 25 sides each. There is still a chance that some dice will point the same member. Then he has to throw them more often.

A NORMAL DISTRIBUTION DETERMINES ANYTHING IN BETWEEN

If the number of possible outcomes is not the 2 of a coin, or the 6 of a dice, but an infinite number, such as the lengths of 17mln people, then you need a continuous probability distribution for all real numbers.

Such a distribution has an infinite number of possible outcomes N for every k observations x and their chances p. Such a 'normal distribution' must condense around an average μ but dilute infinitely to the rare cases.

case	x	f	u=x-μ	(x-μ)²	f(x-μ)²	Gauss	/N	
1	0	1	-7	49	49	3,2	0%	
2	1	14	-6	36	504	20,4	0%	
3	2	91	-5	25	2275	98,2	1%	
4	3	364	-4	16	5824	355,3	2%	
5	4	1001	-3	9	9009	965,9	6%	
6	5	2002	-2	4	8008	1973,0	12%	
7	6	3003	-1	1	3003	3028,7	18%	
8	7	3432	0	0	0	3493,8	21%	μ
9	8	3003	1	1	3003	3028,7	18%	
10	9	2002	2	4	8008	1973,0	12%	
11	10	1001	3	9	9009	965,9	6%	
12	11	364	4	16	5824	355,3	2%	
13	12	91	5	25	2275	98,2	1%	
14	13	14	6	36	504	20,4	0%	
15	14	1	7	49	49	3,2	0%	
	N=	16384	Σ(x-μ)²=	280	57344	=Σf(x-μ)²		
					16384	=N		
				variance	3,5	=Σf(x-μ)²/N		
	μ = 7			σ=	**1,870829**	=Σf(x-μ)²/N		

Fig. 110 Calculation of σ from the frequencies of Fig. 107 and…

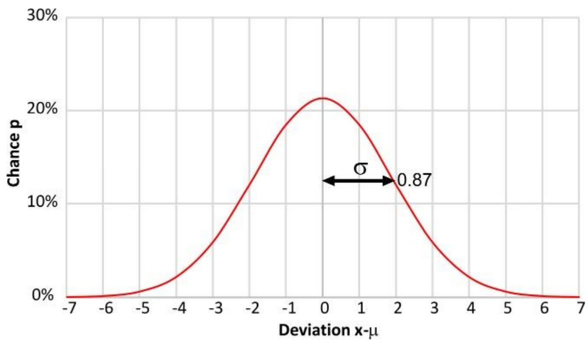


Fig. 111, …its normal Gauss-distribution

Gauss came up with a formula[a] that 'continuously' fills the gaps between the whole numbers (red in ***Fig. 105***, ***Fig. 107*** and ***Fig. 111***).

---

a That formula $\frac{1}{\sigma\sqrt{2\pi}} \cdot e^{-\frac{1}{2}\left(\frac{x-\mu}{\sigma}\right)^2}$ gives the chance of outcome x. In Excel: NORMDIST(x;μ;σ;FALSE). With TRUE the cumulative version is calculated.

7 MATHEMATICS SUPPOSES REPETITION

Newton's 'discrete' numbers at $k = 8$ throws or coins (***Fig. 105***) differ little from a normal distribution, good for $k = \infty$.
The average of all deviations x-μ determines how 'flat' Gauss' formula (***Fig. 111***) is, but if the sum of - and + deviations is zero, then you cannot calculate that average.

Squaring makes everything positive. The square sum of all deviations $\Sigma(x-\mu)^2$ is therefore a positive measure for the total of all deviations of μ. That is on average $\Sigma(x-\mu)^2/N$ ('variance'). N means all cases, write 'n' if it is only a sample of cases.

If you measure the lengths of people in cm, then you get that variance in cm^2.
That is a surface, and the deviation is not a surface, but a length. The square root $\sqrt{(\Sigma(x-\mu)^2/N)}$ is then again in cm. That root of the variance is the 'standard deviation' σ.

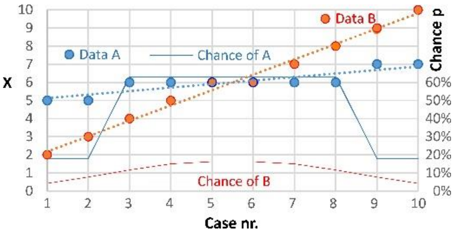
The standard deviation σ has some special characteristics. It is the distance from the average to the 'inflection point' where the graph becomes from convex into hollow. Within the area bounded by both -σ and +σ on both sides, you will find 68.2% of the results. At 1,96σ this is already 95%. The rest is called 5% 'exceedance chance'.

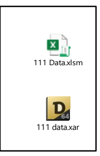
For Gauss (note a p145) you only need to know μ and σ in order to predict the probability of occurrence of each outcome. If you do not know all the outcomes x, but their frequencies f in the neighbourhood of each x (their 'class'), take k instead of x and put another f in the formula: $\sigma=\sqrt{(\Sigma f(k-\mu)^2/n)}$.
If you do know all N results x, then k is x and any f=1, so you can leave out that f.

With the results of a sample of n from a much larger mass N you can already estimate μ and σ quite nicely. You then write m, s, z instead of μ, σ, x. Gauss (m, s) predicts all outcomes within set 'confidence limits'. Comparing your outcomes with that prediction, you can find deviations that require further explanation.

SAMPLES ALLOW CORRELATING 2 DATA SERIES BY PROBABILITY TESTS

You now can also compare *two* different series of outcomes A and B.
For example, ***Fig. 112*** shows two data sets.
Fig. 113 shows the differences, and 'tests' some relations between A and B.





	A	B	C	D	E	F	G	H	J
1		A	B	COUNTA(B2:B11)	10	10	n		number of cases
2		5	2	MODE.SNGL(B2:B11)	6	6	mode		most common result
3		5	3	MEDIAN(B2:B11)	6	6	median		middle result
4		6	4	AVERAGE(B2:B11)	6	6	μ ≈ m	$\Sigma_i z_i/n$	average
5		6	5	AVEDEV(B2:B11)	0,40	2,00	ū	$\Sigma_i(z_i-m) / n$	average deviation
6		6	6	VARP(B2:B11)	0,40	6,00	s^2	$\Sigma i\ (zi-m)^2 / n$	variance
7		6	6		0,63	2,45	s	$\sqrt{\Sigma i\ (z_i-m)^2 / n}$	sample standard deviation
8		6	7	STDEV.P(B2:B11)	0,63	2,45	σ	$\sqrt{\Sigma i\ (x_i-m)^2 / N}$	standard deviation n = N mass
9		6	8	CHISQ.TEST(B2:C11;expected)	94,5%		χ^2	A and B still run a 5.5% chance of being dependent	
10		7	9	CORREL(B2:B11;C2:C11)	90,4%		r	they have a 90% chance of correlation	
11		7	10	TTEST(B2:B11;C2:C11;2;3)	100,0%		t	the average is also the same for measurement errors	
12				FTEST(B2:B11;C2:C11)	0,04%		F	insofar as independent, the variances differ considerably	

Fig. 112 Two series of data A and B, and their normal chances

Fig. 113 Comparative values and tests in Excel

The 'χ^2-test' ('chi-square test') shows that A and B still have a 5.5% chance of actually being one normal distribution (are 'dependent'). The r-test shows 90% correlation.

The t-test shows 100% chance of an equal average, but the F-test signals 0.04% equality in variance and therefore in standard deviation. You may have seen all that already in ***Fig. 112***, but these tests convince with many more data.

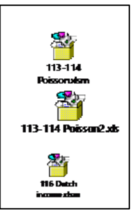
FEW FROM COUNTLESS CASES STILL HAVE A CHANCE TO OCCUR

A year counts 365*24*60*60 = 31 536 000 seconds. If you stay awake, then you will see about 16 frames per second. These are therefore N = 504 576 000 observations.
If you see a lightning (1 to 0.0001 sec) on average 4 times a year in 1/16 of a second, then you would calculate a negligible average probability of 4 out of more than 500 million: practically zero. The complementary chance of no lightning strike is practically 100%.

This is a binomial case (cross or coin, yes or no) of whether or not you see a lightning, but the deviations, variance or standard deviation, are useless. How could you know how much chance you run in an entire year, to see none or 10 lightning strikes?
Such a probability problem with innumerable observations N in time occurs in insurances, waiting times, and the like.

Poisson came up with a formula[a] for a given μ (eg 4) with a standard deviation $\sigma=\sqrt{\mu}$ (eg 2) for each period (eg a year). So, you only need to know μ, but with Poisson that is called λ. That formula gives the chance of k occurrences (**Fig. 114**).

With an average of 4 lightning strikes per year (20% chance) you have still 10% chance that it will be 4 + 2 = 6, but on the other hand 15% chance of 4-2 = 2. That skew division 'collides with the zero limit'. A lightning strike can occur 0 times, but not -1 times.



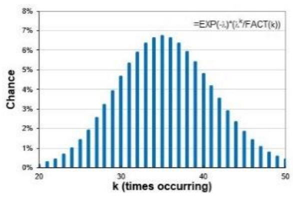


Fig. 114 Poisson at λ=35,5

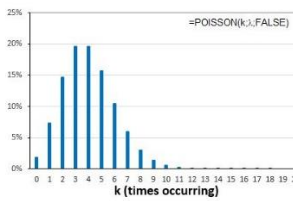


Fig. 115 Poisson at λ=4

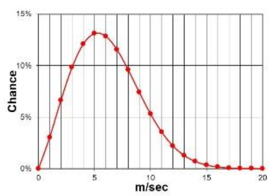


Fig. 116 Weibull[b]

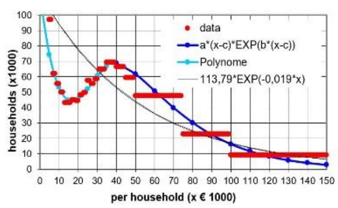


Fig. 117 An income distribution[c]

If λ is far enough from 0, then the distribution seems to be quite similar to Gauss. However, if the average λ is close to 0 (eg 4, ***Fig. 115***), then the Poisson distribution becomes skewed.

NON-NORMAL DISTRIBUTIONS SUPPOSE DEVIATING DEVIATIONS

There are other skewed probability distributions that start at 0, such as the continuous 'Weibull distribution'. For example, it is used for wind velocities (***Fig. 116***).
The wind also cannot blow less than with a speed 0.

The distribution of incomes (***Fig. 117***) is also distorted, but a bureau for statistics often provides data per 'class' (from .. to). In ***Fig. 117*** the frequency classes at the higher incomes, are horizontal lines. The lower incomes are given in smaller classes. Around 15,000 is a dent that would disappear in one large class of €0 to 40,000.
The class-middle would then reasonably be on an 'exponential' downward trend.

a The formula $\frac{e^{-\lambda}\cdot\lambda^k}{k!}$ is calculated in Excel with POISSON(k;λ;FALSE). With TRUE the cumulative version is calculated.
b $P(v,C,a): a * C * v^{C-1} * e^{\{(-a*v)^C\}}$
c $p_1(x,a,f)= a+bx+cx^2+dx^3+ex^4+fx^5$ and $p_2(x,a,b,c)= a(x-c)e^{b(x-c)}$

Exponential functions are usually written as powers of the number e (*Fig 86* p138). In Excel you write e^x as 'EXP (x)'. If you click on an exponential 'trend line' in Excel for the data of ***Fig. 117***, it draws the continuously falling curve $113.79 * e^{-0.019x}$.[a]
This 'regression line' therefore deviates considerably from the more detailed data with a bad correlation.

In the formula $a * e^{b*x}$, a and b (the 'parameters') in ***Fig. 117*** get the values $a = 113.79$ and $b = -0.019$. You should set these parameters differently each year if the data change.
That formula does not *predict* anything yet, but it may be useful in order to estimate intermediate values ('interpolate').
If, after a number of years, you find a trend in the course of the parameters yourself, you can perhaps risk a prediction ('extrapolate').

With a formula $a * (x-c) * e^{b*(x-c)}$ you approach the data after x=40 much better, but before x=40 it is totally wrong (in ***Fig. 117*** that part is omitted).
There ($x \leq 40$), a 'polynomial' function fits much better: $p(x) = 2{,}3x^0 - 81x + 67x^2 + 0{,}37x^3 - 0{,}021x^4 - 0{,}0004x^5$, but that on its turn does not work after x=40. The two functions connected at x=40 together describe the data very nice, but if you do not find trends in all of their parameters, then you still do not have a prediction.[b]

REGRESSION REDUCES DEVIATIONS

In ***Fig. 117*** a trend line in a point cloud is drawn as a global relationship between income and the chance of it. The method of finding a mathematical relation between single data is called 'regression'.

Suppose a shopkeeper notes the average price of his products and his turnover for a few months to find out whether a price reduction is worthwhile (**Fig. 118**)[c].
The simplest is, of course, if that relationship shows a straight line y=ax+b.

month	price	advertising	turnover
1	4	10	18
2	3,75	10	20
3	3,25	12	24
4	3,75	8	17
5	3	12	22
6	3,5	14	21
7	2,75	20	25
8	3	18	23

Fig. 118 Pricing, advertising and sales of a shopkeeper

Excel now gives a trend formula that promises a doubling of turnover if he halves the price. That cannot be true, because if you see the price line in ***Fig. 118*** goes to zero (extrapolate to the top left) he would get a huge turnover according to that formula, if he gives away everything for free.

a This formula is printed with the 'correlation' curve (eg R^2 = 81%) if you have checked these options in Excel.
b Mathematicians do not like this kind of mess.
c The figures from this list come from Buijs(2003)Statistiek om mee te werken(Groningen)Stenfert Kroese p384

That straight ('linear') line is only reasonable (reliability $R^2 = 79\%$)[a] for those 8 observations, so you can interpolate it, but extrapolating may lead to absurdities.

An advertising expert, to whom the retailer has spent a lot of money each month (column 'advertising' in ***Fig. 118***), makes Excel claiming that sales will increase from 20 to 25 if you double advertising spending from 10 to 20.
The shopkeeper feels that something is wrong. Who guarantees that the increase in turnover is not caused by a simultaneous price reduction?
The 'pairwise' relationship between price and advertising per month is missing.

If there are more variables in the game, then statisticians switch to 'multivariate analysis'.

There are many kinds of 'multivariate analysis'.[b] Let us take 'multiple regression analysis'. Excel has an add-in for data analysis that provides a formula for this case, for example turnover = -4.33*price+0.17*advertising+33.63. It shows that a price reduction weights much heavier (-4.33) than advertising costs (0.17) for the turnover of this retailer.

Perhaps there are, however, other variables (purchasing costs, competition, seasonal influences, fashion) that pull turnover up or down.

Moreover, the question remains whether those regression lines are straightforward. Perhaps you can approach some better parabolic, exponential or with a polynomial. In any case, a wrong choice of two variables (such as turnover and advertising) or the omission of others can lead to false conclusions.

More than 3 coherent variables are difficult to grasp, but we have to deal with them on a daily basis. They cannot be represented in one graph. Many people, however, can still make the right decision without calculations, in a situation in which they have to take into account many circumstances at the same time. How do our brains deal with the many data from different senses and memories, weighing them properly?

The increasing understanding of our neural system led computer experts simulate the functioning of nerve cells (neurons) in a mathematical network (see § 29 p163).

In this century, after a period of trial and error, it has produced remarkably useful results. It is an *iterative* process in which the weighting of variables by different parameters is repeatedly being adjusted ('learning').

Let us first demonstrate that small changes of initial values and parameters may have great effect by iteration.

a https://en.wikipedia.org/wiki/Coefficient_of_determination

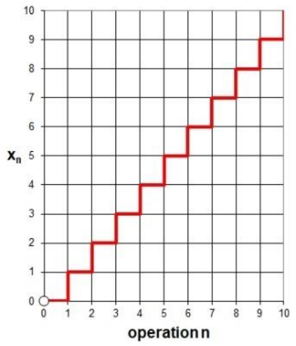
b Slotboom(2001)Statistiek in woorden(Groningen)Wolters Noordhoff calls at 'multivariate analysis' the following methods: multiple regression analysis, principal component analysis, factor analysis, canonical correlation analysis, path analysis, variant analysis, multivariate analysis of variance MANOVA, nonlinear multivariate analysis, covariance analysis, discriminant analysis, linear combinations, interaction effects, GLM General Linear Model , cluster analysis and multidimensional scale techniques.

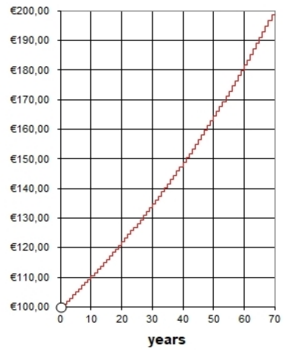
§ 28 ITERATION MAY PRODUCE FRACTAL DIVERSITY

ITERATION HAPPENS EVERYWHERE

If you change a number with a formula and then change *the result* with the same formula, then such a 'feedback' on each previous result is called 'iteration'.
The simplest example is *counting*. Its formula is $y = x + 1$. The previous number is x and y is the result that will serve as x again to get the next y in the next operation.

In order to be able to keep track of the number of iterations, however, you can better write: $x_{n+1}=x_n+1$.[a] If x_n is the previous number (eg $x_n=0$), then x_{n+1} is the next one ($x_{n+1}=1$).
The 'initial value'x_0 becomes one unit larger. The number of iterations passed is 'n'.
If $x_0=0$, then (at $n=10$) x_{10} is also 10. So, the result of *counting* is equal to the number of operations 'n' (if you keep at least 1 as a unit, and you start at $n=0$).
The number x grows stepwise by repeated adding (***Fig. 119***).





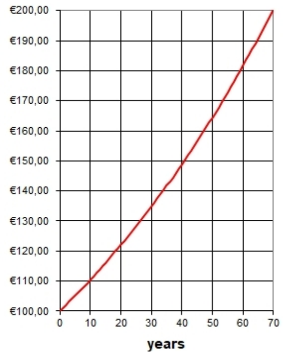


Fig. 119 Counting ***Fig. 120*** $x_{n+1} = x_n * 1{,}01$ ***Fig. 121*** $y = 100*1{,}01^n$

If you do not add, but multiply, then you get 'interest on interest'.
If you put €100 (x_0) at 1% per year, then after 1 year you get $x_1=x_0*1.01=€101.00$,
after 2 years $x_2=x_1*1.01=102.01$ and after 70 years $x_{70}=€200.68$. That is a doubling in 70 years.
More generally, for every year n is the formula: $x_{n+1}=x_n*1{,}01$ (***Fig. 120***).

At a positive interest, there is more every year. However, that operation does not grow in a jerky manner, but gradually, 'exponentially'. You can also write the result after n years as a 'fluid' formula with an exponent n: $y=100*1{,}01^n$ (***Fig. 121***).
After n=70 years, $1.01^{70} = 2{,}006763368395386$ (1.01, 70 times multiplied with itself).
The 'argument' 1.01 must be greater than 1, otherwise your capital will *fall*.

This doubling time of 70 years applies to 1% interest (after the decimal point in 1.01) for *each* capital. In the 'fluid' formula you can make n in smaller steps (even dn, indivisibly small), so that the graph does not rise up jerkily like a staircase per year.
For example, with little steps you can also choose $n=1/365$ or $n=2/365$, so your capital will become $100*1.01^{1/365}$ after one day, $100*1.01^{2/365}$ after two days and so on.

Infinitely iterated adding or multiplying ($n=1\to\infty$) results in infinitely large numbers.
'Infinitely large' by multiplication, however, must be larger than that by addition.

a A computer program also understands 'x:x+1' (x becomes x+1).

Such differences in infinity cannot be made visible in any graph. You only know that they have to be different because the one formula grows faster than the other.[a]
First lesson: there are different infinities!

What happens, if you do not take addition or multiplying iterations, but subtracting and dividing? In the first case: 'countdown' ($x_{n+1}=x_n-1$), the limit is an infinitely negative number. In the second case, however, the repeated application of $x_{n+1}=x_n/1.01$ on its own result is actually multiplying by $1/1.01\approx0.99$. That is a number between zero and one. By iteration, the result, eg $x_{n+1}=x_n*0{,}99$, will drop to *almost* zero, (***Fig. 122***)

This formula slows down if you multiply an ever smaller x_n by 0.99. You never come to zero, however often you repeat the operation, but the 'limit' (supposing to repeat infinitely) is simply zero. Zero seems to 'attract' the result. It is the 'attractor' of this iteration, but not yet a 'strange attractor' that suddenly appears anywhere in the coordinate system, as in chaos and fractals. Then it becomes really interesting.

Endlessly squaring a random number greater than 1, as you could do on an old-fashioned scientific calculator by pressing x^2 each time, shows even faster growth than multiplying each time with the same 1+interest.

Repeating squares ($x_{n+1}=x_n^2$) with x between zero and one ($0<x_0<1$), x *falls* until close to zero (***Fig. 123***). ***Fig. 123*** starts at $x_0=0.6$, but with $x_0=-0.6$ the graph looks almost the same, because the first step $(-0.6)^2$ is also 0.6^2.

If you start with $x_0 = 0.99$, then in the beginning it does not go that fast, it becomes something like ⸜ (***Fig. 124***). With $x_0=1$ it becomes a straight line (–). It remains 1.00, because the square of one is one again.
Second lesson: a small difference in the 'initial value' x_0 can have major consequences through iteration.[b]

See Fig 119

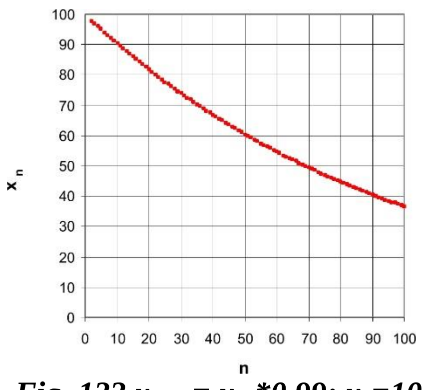


Fig. 122 $x_{n+1} = x_n *0{,}99; x_0=100$

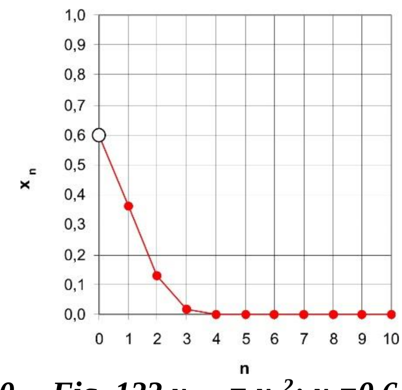


Fig. 123 $x_{n+1} = x_n^2; x_0=0{,}6$

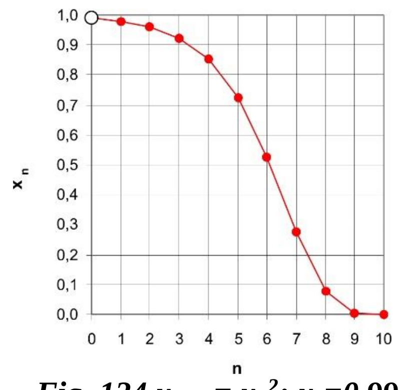


Fig. 124 $x_{n+1} = x_n^2; x_0=0{,}99$

REPETITION CAN PRODUCE DIVERSITY

If you subtract the same constant from the square ($x_{n+1} = x_n^2$-constant), then unexpected things can happen (***Fig. 125*** t/m ***Fig. 127***). If you choose the constant=0, then

a This conclusion is not always valid, but that restriction leads into the specialized mathematical field of transfinite numbers I will not further explore.
b The result of the iteration $x_{n+1}=x_n^2$ is actually something else than the function $y=x^2$, because that results in a parabola.

repeating x^2 beginning with x_0=0.6, and without subtracting anything, it approaches 0 rather directly (***Fig.122***), but what if the constant>0?

In response to Malthus (1798)[a] from the UK, Verhulst(1844)[b] from Belgium tried that for the first time, to get a more realistic picture when population growth comes at the limits of the carrying capacity of the land . He created the 'logistic formula' (↘) of ***Fig. 124***, instead of the usual exponential formula for 'interest on interest' growth. ***Fig. 125*** resembles ***Fig.*** 124, but in ***Fig. 125*** I chose an even smaller difference with 1 for x_0 (0,9999), so that it stays longer near 1. He added a minus sign to ***Fig. 124*** and ***Fig. 125*** **,** making it increasing (↗), but I leave that minus sign for a while.

Until constant=0.2 it remains ↘ but in ***Fig. 126*** **(**constant=1) x fluctuates between two values. Beyond 1.2, that becomes first 4, then 8 different values, and so on, but after 1.3 it becomes 'chaos' (in ***Fig. 127*** the constant is 2). For this graph you can no longer think of a smooth function, you can only iterate and see what comes out.

See Fig 119

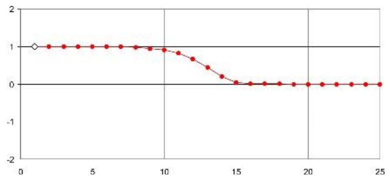


Fig. 125 ***x_n^2- 0; x_0=0,9999***

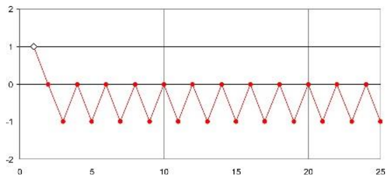


Fig. 126 ***x_n^2- 1; x_0=0,9999***

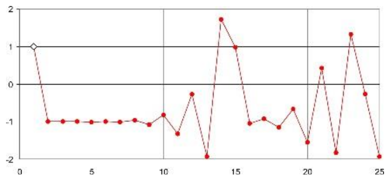


Fig. 127 ***x_n^2- 2; x_0=0,9999***

The smallest change of the initial value x_0 can again yield a totally different graph. It may even be that on your computer something else appears than on mine with other rounding offs. Formulas with a square are not 'linear'. Squaring changes any negative predecessor into a positive number, but subtraction can make it also negative again. That is why these graphs are not smooth curves. The curves are broken, 'fractal'.

Comparing neighboring values or differentiating and integrating does not make sense. The jumping curve is 'not integrable', rather frustrating for classical mathematicians.[c]

I limit myself to iterations with x_0 between zero and one, because then squaring can produce perceptible chaos instead of all kinds of imperceptible infinities.

What happens if you multiply the result of squaring with a constant factor? Not much shocking. At low initial values it seems that every next step strengthens the ↘-shape with the same factor, but it remains a ↘ form. At an initial value=1/factor it is a straight line, but at higher initial values the result soon disappears into infinity.
Infinities cannot be visualized and compared. There is therefore little to experience.

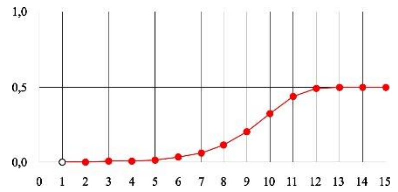
If (with that factor) you *subtract* from a previous result x_n its (each time smaller) squared x_n^2 (x_{n+1}=factor$*x_n$–factor$*x_n^2$), then their difference becomes even smaller,

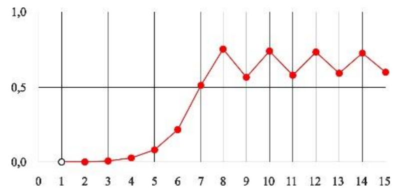
a Malthus(1807)An Essay on the Principle of Population, or a View of Its Past and Present Effects on Human Happiness, with An Enquiry into Our Prospects Respecting the Future Removal or Mitigation of the Evils Which It Occasions(London)Johnson

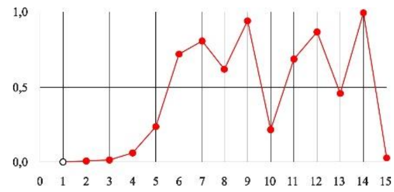
b Verhulst(1845)Recherches mathématiques sur la loi d'accroissement de la population(Nouveaux Mémoires de l'Académie Royale des Sciences et Belles-Lettres de Bruxelles)18 1–42; Verhulst(1847)Deuxième mémoire sur la loi d'accroissement de la population(Mémoires de l'Académie Royale des Sciences, des Lettres et des Beaux-Arts de Belgique)20 1–32.

c Peitgen(1986)The beauty of fractals(Berlin)Springer; Steward(1989)Does God Play Dice? The Mathematics of chaos(London)Penguin Books Tennekes(1990)De vlinder van Lorenz(Bloemendaal)Aramith; Gleick(1987)Chaos:making a new science(New York)Viking but something unexpected can happen. The difference between consecutive values of x can then hardly be distinguished. If you both magnify each time with an equal factor, then you can see unexpected things again (***Fig. 128*** - ***Fig. 130***).

See Fig 119







X_0 = 0,001

Fig. 128 $x_{n+1}=2*x_n-2*x_n^2$ ***Fig. 129*** $x_{n+1}=3*x_n-3*x_n^2$ ***Fig. 130*** $x_{n+1}=4*x_n-4*x_n^2$

If you choose factor=0, the result will of course also remain 0. If you choose factor=1, then little happens too, because you can just omit such a factor. A graph arises that runs from each initial value x_0 with ever smaller differences towards zero.
The differences towards zero are then not perceptible.

The factor must therefore be greater than 1 in order to be able to enlarge the result at every step. Every larger factor counts considerably, because it does not enlarge (or shrink) x_n-x_n^2 once, but with each step again.
The enlargements themselves then become larger and larger.

In the figures ***Fig. 128*** - ***Fig. 130***, the influence of factors 2, 3 and 4 is shown. The result is now very sensitive to the initial value x_0. In these figures I used x_0 = 0.001. That causes a great difference with x_0 = 0.000, because then every x_n stays zero.
With such a small initial value, the formula needs a few steps to get started.
The minus sign ensures *growth*.

With a factor 2 you get an orderly rising logistic (ʃ) curve (***Fig. 128***). It is also known that populations start to fluctuate when they reach their local limit to growth.
The weakest plants, animals *and* their predators or people die en masse, so that the strongest get room again, but their offspring in turn runs against the limits. It seems that this formula is made for that, because that happens with a factor=3 (***Fig. 129***).

In populations that reproduce quickly like insects, you get a chaotic up and down jump, and that is simulated at a factor=4. With this formula you could simulate each population by looking for the right factor. But ..., there is another value in the game, and that is never exactly enough to measure in the harsh reality: the initial value x_0.
This has the following effect on factors 2, 3 or 4.

If you choose a factor=2, the result stabilizes after a number of steps at 0.5 (***Fig. 128***). Those first steps can smoothly go up to 0.5, but they also do not jump up and down fluently. That depends on the x_0 you choose.

> At initial values smaller than 0.1 it becomes a kind of 'logistic curve' (ʃ) that is known by population growth: first slowly, almost horizontally growing, then quickly (almost exponentially) and finally slowing down to 0.5 if the population limits of their sources of existence approach. Then, it remains 0.5 (***Fig. 128***).

If you start at x_0=0.5 (1/2), it becomes a horizontal straight line: it remains 0.5.

If you choose x_0 greater than 0.5, it first jumps up and down before it remains at 0.5 in each subsequent step.

If you choose a factor=3, after a few steps x_n jumps up and down between two almost equal values (***Fig. 129***), but that starts already with factor=2.8.

At small x_0 initial values, it can still start flowing smoothly at the beginning, but sooner or later the jumping starts (***Fig. 129***). This also happens in populations that have reached the limits of their sources of existence.

If you choose the initial value x_0=0.333 .. (1/3), it becomes a straight line again. This always happens when the factor is a multiple of x_0, but beyond those few initial values x_n jumps down and up.

If you choose a factor = 4, then you have chaos again (***Fig. 130***).
If you also make the smallest change to the initial value x_0, then completely different values follow after sufficient steps. The graph jumps seemingly unpredictably between all sorts of values, sometimes flowing a little, but usually discontinuously.

The result is deterministic and predictable, if you know the initial value exactly (with an infinite number of digits), but for practical applications they can never be determined exactly enough. For the first steps the chaos starts at factor=3.5, but the chaos becomes endless from 3.57. This confused the mathematicians. You repeat the same operation, and yet the result is no longer tied to a rope.

CHAOS SHOWS SOME ORDER

In 1980 Feigenbaum[a] brought some order in the chaos.

See Fig 119

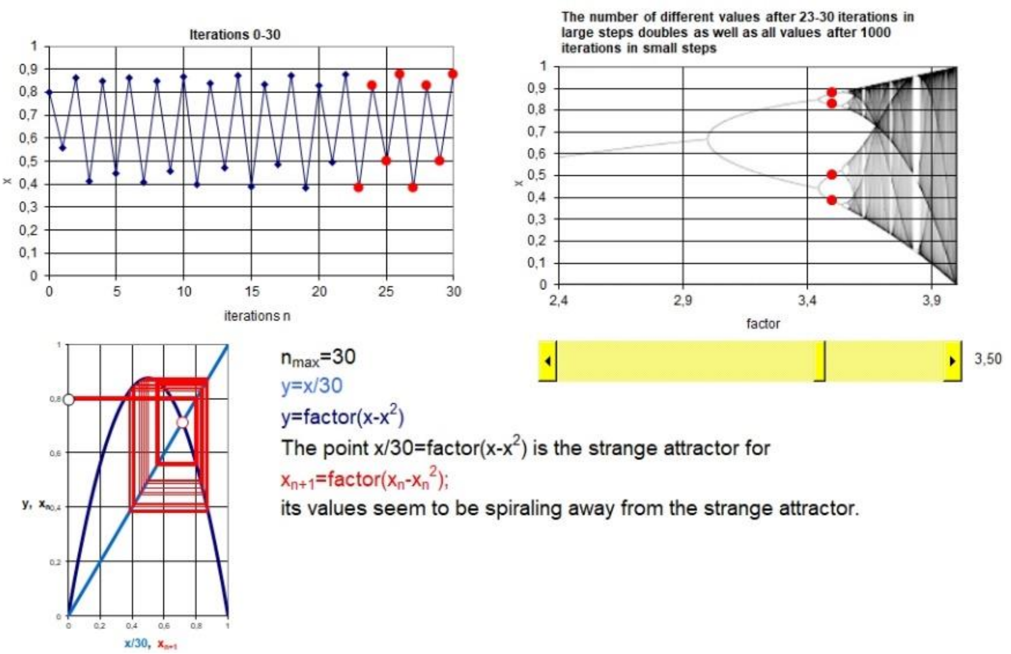


Fig. 131 Doubling (bifurcation) of the number of chaotic values x in a fig tree

a Feigenbaum(1978)Quantitative Universality for a Class of Non-Linear Transformations(J Stat Phys)19 25–52

Smale[a] had already noted that the number of different values x_n in the vicinity of factor = 3.57 doubles after a number of steps and with ever smaller intervals ('bifurcation'), as in a tree whose twigs divide always into two parts (***Fig. 131***). After an operation called 'renormalization', each preceding branch with the same shape is 4.669 201 609 times larger.

That 'Feigenbaum number' occurs in many iterations. This is, for example, good to know when there are population fluctuations, or when the energy of a flow at an edge is transferred to ever smaller waves ('turbulence'), such as in pipelines and at wind on the earth's surface. That tree representation of self-uniformity at scale levels that are a factor of 4.669 ... separated was appropriately called 'fig tree' honouring Feigenbaum.

TWO VARIABLES PRODUCE A JULIA SET

Already in 1918 Julia[b] from France came up with the brilliant idea to depict two interdependent iterative formulas in a plane as x and y coordinates: $x_{n+1}=x_n^2-y_n^2+p$ and $y_{+1}=2*x_n*y_n+q$ (***Fig. 132 - Fig. 140***). That is where beautiful figures ('fractals') can emerge if you choose the correct initial values x_0 and y_0. To determine this, however, you have to dive deep into mathematics, so that I leave it to the experts. There are simulators on the web that do that for us.[c]

The resulting figures already tell so much that they themselves bring a certain order in the chaos of an infinite number of possible Julia figures. I limit myself here to the influence of the addition parameters p and q on the resulting figures. If p and q are both zero, then you get a clean, filled circle, a disk with all points connected to each other. For the time being, let's just keep q zero and only vary p.

If you choose p = 0.2, then that circle distorts to ***Fig. 132***.

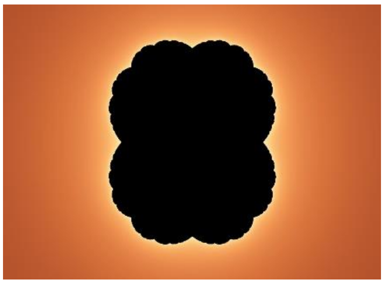


Fig. 132 Julia p=0,2; q=0

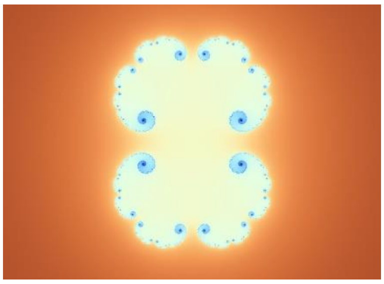


Fig. 133 Julia p=0,3; q=0

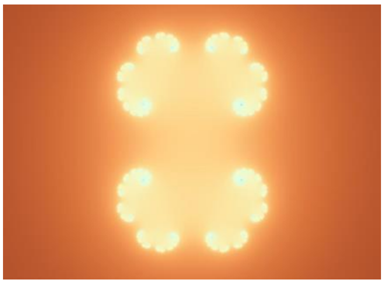


Fig. 134 Julia p=0,4; q=0

At p=0.3 the parts of it are separated from each other and there are all kinds of spiral details visible that repeat themselves to the smallest details when you enlarge the figure (the iteration steps decrease). At p=0.4 everything seems to have come loose. Now the negative values of p. So you can stick it before the previous series.
I take only a somewhat larger distance between the examples, namely 0.5.

a Smale(1974)Sufficient conditions for an optimum((Proc Sympos Appl Topology and Dynamical Systems, Univ Warwick, Coventry)p 287-292
b Julia(1918)Mémoire sur l'iteration des fonctions rationelles(Journal de Math. Pure et Appl)8 (1918), 47-245
c For the next figures I use http://fraqtive.mimec.org/downloads

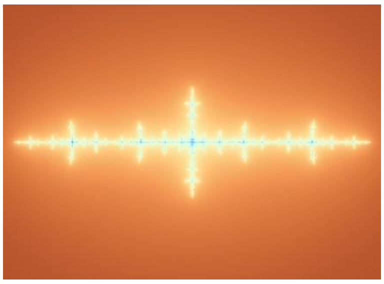


Fig. 135 Julia p=-1,5; q=0

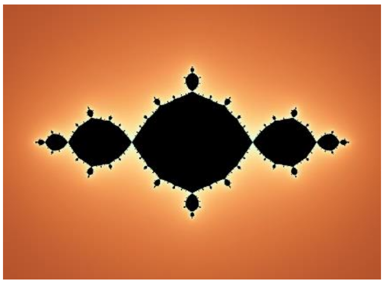


Fig. 136 Julia p=-1; q=0

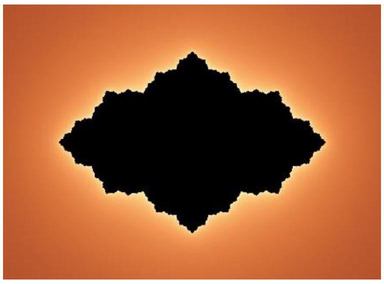


Fig. 137 Julia p=-0,5; q=0

I leave the interpretation of these differences between positive and negative values of p to the reader. I will now vary q with a constant value p=-0.75.
There are nice pictures.

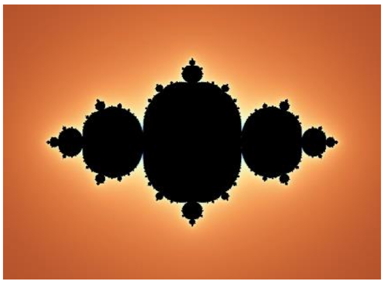


Fig. 138 Julia p=-0,75; q=0

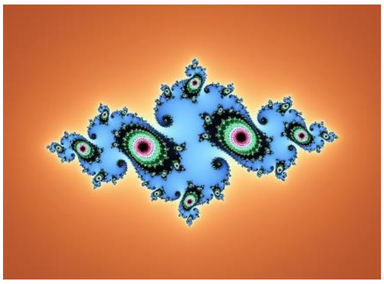


Fig. 139 Julia p=-0,75; q=0,1

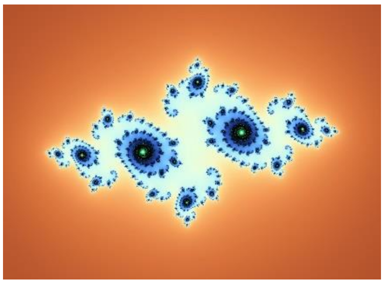


Fig. 140 Julia p=-0,75; q=0,2

Fig. 138 (p=-0.75) is thus exactly between ***Fig. 136*** (p=-1) and ***Fig. 137*** (p=-0.5).
If we now hold p the same (p=-0.75) and q varies between 0 and 0.2, q appears to skew the symmetry axes, but at even higher values they also fall apart. The negative values of q fall apart exactly as the positive ones. They also produce the same figures with their negative values, but their symmetry is mirrored by the minus sign.

All these Julia figures have symmetry as a common characteristic. In the area of falling apart, you also often see repetitive spirals, if the simulator gives at least one color at different degrees of connection. Black usually means that all pixels are completely connected to each other.

THE MANDELBROT SET IS A CATALOGUE OF COHERENT JULIA-IMAGES

The number of figures you can produce by varying Julia's p and q is dizzying and cannot be summarized in flowing functions. You can only wait and see what comes out of iteration. Julia has been forgotten by his fellow mathematicians for 60 years, until Mandelbrot[a] came up with the luminous idea to depict p and q in a graph on an x- and y-axis, and to capture the boundaries of falling apart from each other (***Fig. 141***).

a Mandelbrot(1977)Fractals: Form, Chance and Dimension(New York)Freeman & Co
Mandelbrot(1982)The Fractal Geometry of Nature(New York)Freeman & Co

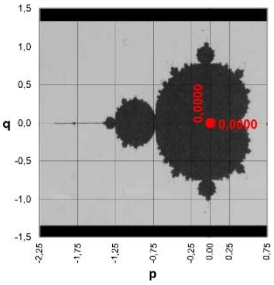


Fig. 141 p and q in the Mandelbrot set

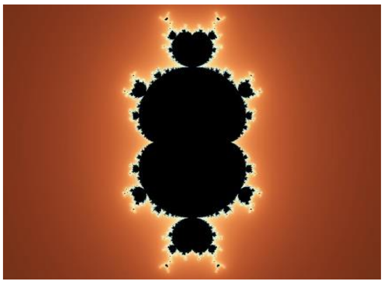


Fig. 142 Mandelbrot set for third powers

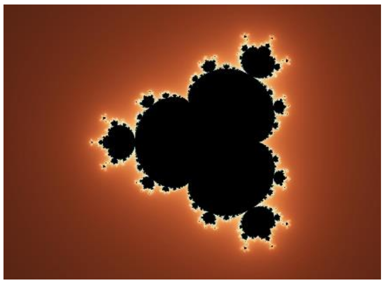


Fig. 143 Mandelbrot set for forth powers

That is where the most interesting images appear. It became the famous Mandelbrot set (***Fig. 141***) and Julia was back in the spotlight again. Unfortunately, Julia did not experience that anymore, because he had died shortly before in 1978. This revolution was a stimulus for research to chaotic formulas. Now there were not only formulas with squares, but also with higher powers for which you could make Mandelbrot sets (***Fig. 142*** and ***Fig. 143***).

Several additions to the first formula brought in other variants on the original Mandelbrot set (***Fig. 144*** t/m ***Fig. 146***).

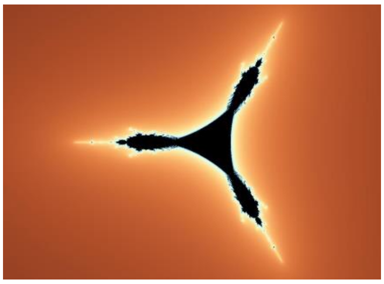


Fig. 144 Conjugate Mandelbrot set

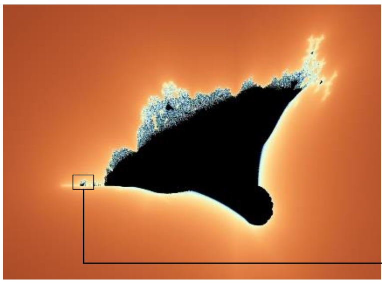


Fig. 145 Burning ship Mandelbrot set

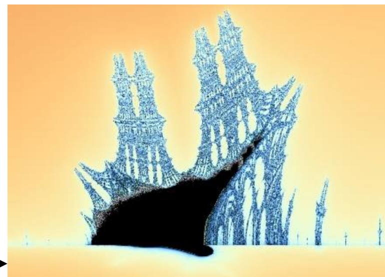


Fig. 146 Enlargement of the extreme left part of Fig. 145

Each point in these figures is a combination of p and q producing a different Julia image, but any detail of these infinite 'catalogs' of coherent Julia images are also fractals that you can endlessly enlarge by taking smaller steps.

This yields other (now Mandelbrot) images such as ***Fig. 146***. In that you recognize the entire image in unexpected places in a different context.
Still no one can explain how or why that happens.

THREE VARIABLES PRODUCE A LORENZ SET

Weatherman Lorenz[a] understood already in 1963 that in order to simulate the unpredictable weather as a kind of shifting Julia-figure, you need to know exactly at least *three* initial values such as atmospheric pressure (x_0), temperature (y_0) and humidity differences (z_0).

Any phase of weather can then be plotted in a three-dimensional x-y-z graph, the 'phase space'. Any next phase connects to previous one, but with the smallest

a Lorenz(1963)Deterministic nonperiodic flow(J Atmospheric of the Sciences)20 130-141 difference in initial values x_0, y_0 and z_0 after a few steps it develops completely different.

He now devised three interdependent formulas in that x-y-z phase space, with parameters s, r, b:

$$x_{n+1} = x_n - s * (x_n - y_n)$$
$$y_{n+1} = y_n + x*(r - z_n - y_n)$$
$$z_{n+1} = z_n + (x*y - b*z_n)$$

The resulting curve is then the 'phase portrait' of this 'system' of equations (***Fig. 149***). If you make the steps small enough and then only look at the first 500 steps in the x-y plane(***Fig. 147* - *Fig. 148***), then you already understand what else can happen.

If you keep r and b at zero and only s varies, you will see a spiral that seems to revolve around the axis x = 0. They now call this the 'Lorenz attractor'.

See Fig 119

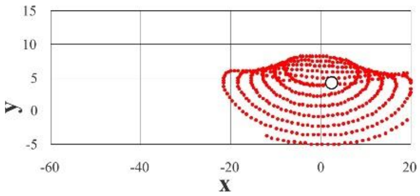


Fig. 147 Lorenz s=30;r=0;b=0

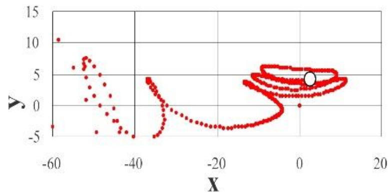


Fig. 148 Lorenz s=30;r=3;b=0

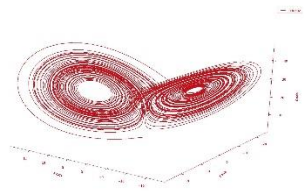


Fig. 149 Phase portret

The strange thing is, that wherever you start in the phase room outside this curve, you will end up with another butterfly of which you can look up the parameters. At s=10 it looks like a sloppy spring with more or less regular windings, but at s=30 it has become a spring with ever wider turns (***Fig. 147*** is the x-y map).
Above the s=30, those windings only become wider and wider.

If at s=30 you start increasing the r from zero, then at r=1 almost nothing happens, but at r = 2 a winding loosens to form an own spiral at r = 3 (***Fig. 148***).
That second spiral revolves around another axis. Changing b then has little effect, the image only distorts a little. Lorenz first examined the behavior of r (the 'Rayleigh number') at s=10 and b=3/8.

With many more steps you get ***Fig. 149***.[a] With the parameters s, r and b you can make infinitely many phase portraits that have little to do with the real weather, but it can help to understand why weather forecasting is so difficult.

These x, y and z are not the only dimensions that play a role in the weather forecast. There are many more. The weather in the longer term can only be predicted if you could precisely measure or determine all parameters and initial values with an infinite number of digits after the decimal point. And that is not possible.

a How that works is beautifully explained in http://www.chaos-math.org/en/chaos-vii-strange-attractors

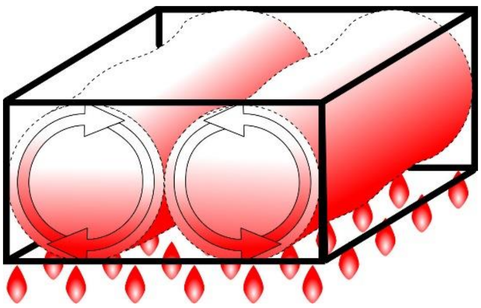
At most, you can repeat the phase portrait repeatedly and calculate the probability of ending up in a certain phase (for example a whirlwind). There is some regularity, but where on Earth that will probably arise, is not yet certain.

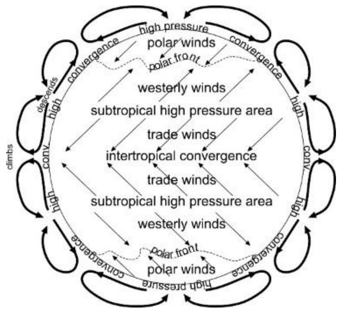
BÉNARD CELLS SHOW EMERGING ORDER IN CHAOS

Lorenz was inspired by a bowl of water that Bénard[a] in 1908 heated slowly and very evenly. If you heat up a square bowl of water, the temperature of the water will first rise from hot below to cold upwards ('conduction'). That is the first phase.

In the second phase the water sets in motion ('convection') because hot water is slightly lighter than cold water and therefore rises (especially in the middle).
That hot water flows off to the walls cooling off and thus creates a cycle that, if you are lucky, makes the water run in two cylinders (***Fig. 150***).
Such cylinders can also be found on a much larger scale in air (***Fig. 151***).

However, that system is soon disturbed when further heating up.
The cylinders start to wave in the length and finally the water starts bubbling chaotically. That is then the third phase.





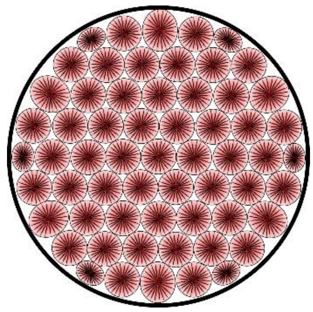


Fig. 150 Cylindric convection *Fig. 151 The atmosphere* *Fig. 152 Bénard cells*

When these phase transitions take place depends exactly on the temperature difference between bottom and top, the height of the tray, the gravity, the expansion of the water, its viscosity and its willingness to mix.
These influences are nicely summarized in a formula that results in the so-called Rayleigh number. And that was Lorenz's parameter r!

If r is less than 1 (***Fig. 147***), then the water is not yet moving, there is only conduction of the heat upwards. Between r=1 and 24.06 you may see two cylinders running.
In terms of Lorenz, a second 'attractor' comes in (***Fig. 148***). If r becomes greater than 24.74, then it becomes chaos. The spirals of Lorenz do not run to a center, but go to infinity, where somewhere a third strange attractor appears to have started operating.

Bénard, however, used a round tray, which, if you're lucky, gives a pattern of round, donut-like cells that fit in a hexagonal pattern (***Fig. 152***).

GLOBAL ORDER COMBINES LOCAL CHAOS IN AIR CIRCULATION

If you look at the dominant global airflow in general, cooling air will drop down at the poles and heated air will rise at the equator, so that a constant air circulation is created.

---

a Bénard(1900)Les tourbillons cellulaires dans une nappe liquide(Rev Gen Sci pures et appl)11 1261-1271 & 1309-1328

The air risinging the tropics, however, cools down earlier on the way to the poles and descends to the subtropics, in order to find its way to the north and south at the surface of the earth (for us observable as wind). As a result, three toroidal air circulations develop on each of the two hemispheres. They interlock as gears (***Fig. 151***).
You also need an odd number of gears to turn clockwise again.

During that process, however, the entire atmosphere also moves with the earth from west to east. At the equator the earth's surface moves with 1600 km/hour, but in the temperate zone with 1000 km/hour.

In a northern latitude the dominant wind towards the pole is deviated by its higher speed from the equator to the east. The wind then comes from southwest due to its eastward velocity impulse from the larger equator circle. South of the subtropics, on the other hand, it comes from the northeast.

Sailors on their way to America have been sailing south for years to visit the 'trade winds' (NE passates) and from America first to the north and from there back to Europe to use the westerly wind (***Fig. 151***). The ocean water can also be pushed up by these winds, so that a large ocean swirl (the Gulf Stream) gives the ships a boost under water.

LOCAL WHIRLS EMERGE IN A REGULAR FLOW BEHIND OBSTACLES

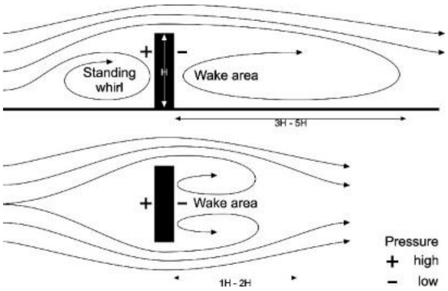


Fig. 153 Whirls behind obstacles

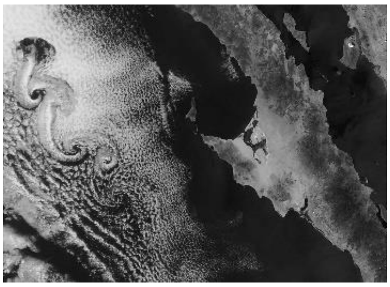


Fig. 154 Kármán vortex street near California[a]

At the boundary of the atmosphere and the earth's surface, all kinds of smaller whirls are created in the air behind mountains and buildings as counter-rotating smaller gears (***Fig. 153***).

There, the accumulated air seeks a way out in a corkscrew movement upwards or passes behind the obstacle in a series of vertical whirls (a von Kármán vortex street, ***Fig. 154***).

REALITY HAS MORE VARIABLES THAN A MODEL

In order to bring Bénard's closed box closer to the open reality at least a few parameters should be added: the varied speed and the endlessly varying relief of the earth's surface, for example. We do not have to think about predicting with so many small differences in initial values with great impact.[b]

a http://fuckyeahfluiddynamics.tumblr.com/post/1093448891/the-von-karman-vortex-street-isnt-just-found-in
b Tennekes(1990)De vlinder van Lorenz(Bloemendaal)Aramith

Wolfram (2002) had not yet given up hope.[a]
In more than 1250 pages, he explains little more than that we have to reverse the case and compare all conceivable fractal and chaotic structures with what we find in reality, until we have found something that *looks* like it.
That may take a pretty long time for his internet association of picture viewers.

In fractals the ever recurring spirals are striking and we find them in many real movements as well. That is obvious, if similar processes repeat themselves on an increasingly smaller scale, but that is only formal similarity.
Nature's repetition is not exact. As soon as semipermeable membranes develop in the evolution, the processes on both sides will differ.

If membranes selectively close a cell, then other laws apply.
If membranes develop within them, numerous new environments can arise with their own laws.

The parameters for pressure, moisture content, temperature difference, size, the expansion of material, its viscosity and the willingness to mix, shift everywhere. Especially that willingness to mix is hampered by membranes, and that throws a poison in the food of the chaos optimists.

SIMILARITY IS NOT YET ORGANIZATION

With life phenomena, there is rather a tendency to unmix by separation, to give different processes their own optimal context.

Entropy (a physical probability term for disorder) is decreased on a small scale, paid with increased disorder outside the closed space.
There are organs and organisms with different functions and information exchange (§ 28). An organization arises, and that is totally different from (self) conformity.

Trees and their leaves may look similar, but each tree is different and each leaf on one tree is different. Propagation may be reminiscent of self-uniformity, but you are definitely different from your parents, even if you resemble them.

Every species is different and within each species each specimen is different. Moreover, each copy also ends up in a different context, which also means that its history and learning experience will be different.

Counted in millions of years, your ancestors are even a different species.
The formula for evolution is simple: procreate and die.
That propagation must yield variants. What survives evolves further, the rest dies out.

That formula does not work with uniformity, but only with variation.
Exact cloning does not produce a new species.
It is a dead-end street as soon as predators die with their preys.

a Wolfram(2002)A new kind of science(Champaign)Wolfram media

7 MATHEMATICS SUPPOSES REPETITION

Iteration sometimes produces astonishing self-similar patterns that remind of natural phenomena. It is, however, based on the *exact* repetition of moves and should not surprise us. Repetition is common, but never exact in living nature, and repetition is something else than self-organization (forming organs, organisms, organizations).

It is at most pattern formation. Self-uniformity on different levels of scale such as spirals and whirls are rare in living organisms.

In the society of different organisms, studied in ecology, it sometimes *looks* like that. There is a lot of repetition, but it is never the same.

Between the scale levels with a nomial radius of 3000km to 30m, the human traffic network has a hierarchy that is sometimes roughly coincidental with a factor of 3 of self-similar hierarchy[a], but that is based on simple human optimization[b].

Ecological phenomena must be studied separately at every level of scale. Otherwise you may overlook the trap of a scale paradox (***Fig. 6*** p18): the potential reversal of conclusions on a three times larger scale.

The patterns on 1m radius may seem equal to those on 10m radius, but different on 3m radius. In that case you must conclude substantially different phenomena falsifying your generalisation.

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a Jong(2012)Diversifying environments through design(Delft)TU second thesis p165
b Nes;Zijp(2000) Scale factor 3 for hierarchical road networks a natural phenomenon?(Delft)Trail Research School.

§ 29 A NEURAL NETWORK CORRECTS ITS SUPPOSITIONS

AN ARTIFICIAL NEURAL NETWORK SIMULATES THE BRAIN

An 'Artificial Neural Network' (ANN) is a simple mathematical simulation of nerve cells ('neurons') interconnected with conductors ('axons') in a living organism.

Every human contains an estimated 100 billion neurons, each with many incoming and outgoing connections with other neurons, senses, muscles or organs.
They can correct their connections by weight and, moreover, allow them to die or arise (the latter does not yet function in the artificial simulation).

In a neuron, the incoming signals are combined, and the neuron determines to what extent this combination should be passed on as an outgoing signal to a next layer of neurons (weakened or strengthened).

A large artificial neural network (ANN) can contain 1000 neurons, each with a limited number of unchangeable incoming and outgoing connections.

The input is a set of patterns, the output is their categorization
The input (from observations) of the ANN is a table with numbers 'normalized' between 0 and 1 ('scaling'). Each row of that table forms a pattern of values, for example the sequence of number codes for the successive colors in a old fasioned windows icon (16x16 = 256 pixels). So each pattern *row* contains a different icon. Each *column* of the table represents a location bound pixel.
Such a pixel column is called 'input neuron'.The aim is to recognize that pattern.

There are then 256 input neurons (for each pixel in the same place in all icons). They pass the color code in each column for each row into a smaller number (for example, 100) of 'hidden neurons' (the 'hidden layer' of the ANN).
Each hidden neuron thus receives 256 signals (numbers) of the 256 input neurons per input line and combines them into an output signal to a next layer of neurons.

Each part of a pattern is taken more or less serious for recognition
However, the neurons of a hidden layer do not attach the same value or 'weight' to each incoming column signal. These weights are initially random, but they are later adjusted by an iterative feedback 'learning process'.

Every hidden neuron has its own preliminary preferences, and resistances against the incoming signals. Each neuron in the 'hidden layer' weighs the (for example 256) incoming signals (columns, color codes per located pixel, numbers between 0 and 1) with their own list of provisional weights per column.
These weights are adjusted in a subsequent round of calculations.

How does such a hidden neuron combine all those (eg 256) signals into a single outgoing signal (number) for the next layer of hidden neurons? It multiplies each incoming signal with the corresponding provisional weight. It adds up these products.

That sum is edited with a formula[a] that gives them a value between 0 and 1 ('scaling' or simply 0 or 1). The result is passed to the neurons of a subsequent layer.

Recognized errors determine what has to be taken more serious and what less
The next layer can be a smaller number of hidden neurons that do the same with the results of the previous layer, until it reaches a single neuron as the last layer.

This 'output neuron' then also has its own list of provisional weights, with which the output of the ANN is determined in the same way as the outcomes of the previous layer for each row (pattern, eg windows icon).

What you can do with that end result then depends on the pattern that you want to be recognized in the rows that were entered at the beginning. Assuming that you want the ANN to recognize the character A in the entered patterns (the 16x16 pixel icons), you have to give each row with the pattern that looks like an A the value 0 (1 if not).

This creates a column of ones and zeroes ('desire', desired outcomes) in addition to the list of input values of the ANN. You subtract that from the output values that ANN found, in order to find a list of deviations.

The positive square of each deviation is called 'error'. The sum of all those errors you share by their number to find the average error ('Mean Squared Error' or 'MSE').

Training ⇓ recognizing serious indicators from known examples
Now you can adjust all weights so that MSE is as small as possible. A computer can do that for you.[b] That does not happen at once. After each adjustment you will see MSE (the percentage of errors) become smaller. It adjusted all weights a bit.

You may specify in advance how many rounds it has to make.
If you are not satisfied (for example, if the MSE is not smaller than 0.01 or 1% chance of errors), you simply put it back to work.

This process is called 'training the neural network'. The network started with random weights. That stands for a network that does not 'know' anything yet.

As soon as the chance of errors is less than 1%, the network has 'learned' to recognize the character A almost faultlessly. That knowledge is stored in the table weights that determine how seriously the neurons have to take their input to make no mistakes.

Testing ⇓ applying serious indicators on unknown examples
You can now test that without giving the right answer.
If you keep all adjusted weights at MSE = 0.01 and add a new pattern row to the input list, without your corresponding good (0) or error (1), then that output is 0 ('this is an A'!) or 1 ('this is not an A'!). You then have a 99% chance that that is true.

---

a For example $1/(1-e^{-1})$.

b In Excel, for example, there is a 'solver' plug-in that traverses all formulas that have passed the input on the way to the output, and adjusts the weights used to minimize the end result, maximize it, or add the value you can choose.
In this case, you want to make the average error (MSE) as small as possible. So you choose 'minimize'.

How it works, probably nobody can explain to you, but it works, and it is being used on a massive scale.[a]

Neural networks are used in order to recognize patterns

For example, credit providers have many characteristics of their debtors such as age, home ownership, gender, and so on.
From experience, they also know who will or will not pay back in time.

The question is of course, whether a pattern for defaulters can be recognized in the row of features per person. It is better not to give a loan to that risk group.

For example, you can also recognize a pattern in:
- the course of stock prices of various funds in the past and respond to this;
- the sale of products in different seasons, holiday periods, and so on;
- the course of the weather in different weather conditions in previous days;
- properties of plant species to trace their name.

The last application is a classification problem. That is best served by more than one hidden layer. They sequester to a result successively. Different problems may therefore require different network configurations. Many different suitable configurations have been found in the human body for various tasks.

For example, 'circular configurations' are held responsible for our memory.
In addition, the neurons and axons can also be very different and their connections can change. Connections can degenerate or be newly created.

Our neural system is differentiated and flexible in details, but the *number* of neurons is largely fixed from birth.

If our pattern recognition proceeds according to the scheme of artificial neural networks, it could for example explain how we combine the totally different information from different senses into the constant awareness of a variable object ('synaesthesia').

You can now also imagine how the actions of dozens of muscles are coordinated as a training-based pattern into one specific activity.

EVEN IF YOU KNOW HOW IT WORKS, YOU STILL MAY NOT UNDERSTAND HOW IT WORKS

Such a mathematical simulation of biological examples can lead to other assumptions about our functioning. It appears to be a barely comprehensible alternative to current mathematical optimization techniques.

The ANN expresses the weights in numbers, but our own neural network uses chemical reactions. The ANN adjusts these numbers in a round of mathematical

a Choong(2009)Build Neural Network with Excel(WWW)XLPert Enterprise provides a clear explanation for some operating ANN-applications in Excel. These are downloadable from http://www.xlpert.com/buy-now.html for a small fee.
Professional software is offered via http://www.neurosolutions.com/.

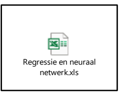
feedback operations ('solver' in Excel). How does that feedback work chemically in a living organism? I cannot answer these questions.

YOU CAN SIMULATE A SIMPLE NEURAL NETWORK EVEN IN EXCEL

If you want to present to ANN the list of the shopkeeper from ***Fig. 118*** (p148), you first have to convert that list (***Fig. 155*** **BCD**) into numbers between 0 and 1 ('scaling' in columns **H, I,** and **J**).

The shopkeeper must specify whether (**E**) is satisfied (0) or not (1). In this case he is satisfied when the turnover minus advertising (**E**) is greater or less than 10, but ANN is not aware of that motive. She only sees the patterns of **H, I,** and **J**.

ANN' now becomes the student you will train and test.[a]



	A	B	C	D	E	F	G	H	I	J	KLMNOPQRSTU
1	month	turnover	price	advertising	t-a	fill in the wish list: 1 of 0		turnover	price	advertising	
2	1	18	4,00	10	8	1	too little profit	0,13	1,00	0,17	
3	2	20	3,75	10	10	0	OK	0,38	0,88	0,17	
4	3	24	3,25	12	12	0	OK	0,88	0,63	0,33	
5	4	17	3,75	8	9	1	too little profit	0,00	0,88	0,00	
6	5	22	3,00	12	10	0	OK	0,63	0,50	0,33	
7	6	21	3,50	14	7	1	too little profit	0,50	0,75	0,50	
8	7	25	2,75	20	5	1	too little profit	1,00	0,38	1,00	
9	8	23	3,00	18	5	1	too little profit	0,75	0,50	0,83	TEST RULE
10					B9-D9			(B9-B$12)/(B$11-B$12)			
11	MAX	25,00	4,00	20,00	ROUNDDOWN(MAX(D$2:D$9);0)						
12	MIN	17,00	2,00	8,00	ROUNDDOWN(MIN(D$2:D$9);0)			normalized values			

Fig. 155 The wish list and the scaling into normalized values in Excel

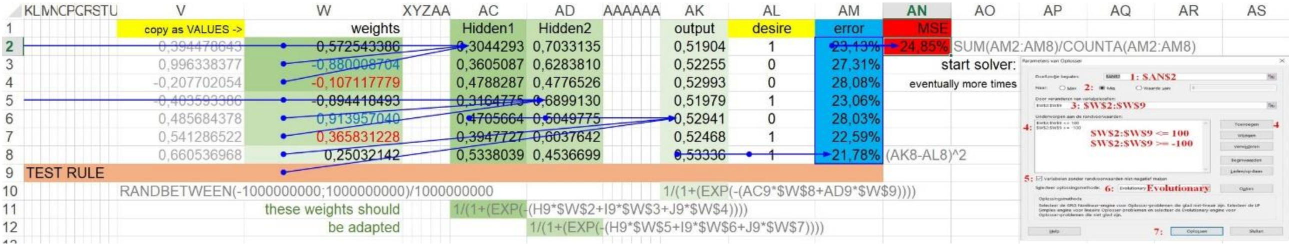
You can teach ANN

You first teach ANN how she should evaluate the patterns from month 1 to 7.
The eighth month you keep as a test rule to see if ANN shares the judgment of the shopkeeper with the experience of a pattern that is unknown to her. You can also deduce that from 'sales minus advertising', but ANN has no idea of that motive.
She only sees the patterns H, I, J evaluated with a 1 or 0 (1 means 'too little profit').

Fig. 155 and ***Fig. 156*** together give a complete picture of this simple ANN (6 neurons) in Excel. It consists of the three scaled Input neurons (the columns H, I and J of ***Fig. 155***). ***Fig. 156*** shows a list of provisional weights, two hidden neurons (Hidden 1 and 2) and one Output neuron.

Hidden 1 and 2 (in ***Fig. 156*** distinguished by shades of green) now come into action. They will both assess every input of the 3 Input Neurons, each with their own weights. The Output neurons will in turn produce the results from Hidden 1 and 2 with two different weights processing output. From that output, the wish list 'desire' is subtracted, so that only the deviations remain. The square of each deviation is called 'error' and the mean of those squares is called 'MSE'.

a This simple example has been worked out in Excel according to the more comprehensive scheme of Choong(2009)Build Neural Network with Excel(WWW)XLPert Enterprise.



	KLMNCPCRSTU	V	W	AC	AD	AK	AL	AM	AN	AO
1		copy as VALUES ->	weights	Hidden1	Hidden2	output	desire	error	MSE	
2		0,394478643	0,572543386	0,3044293	0,7033135	0,51904	1	23,13%	24,85%	SUM(AM2:AM8)/COUNTA(AM2:AM8)
3		0,996338377	-0,880008704	0,3605087	0,6283810	0,52255	0	27,31%		start solver:
4		-0,207702054	-0,107117779	0,4788287	0,4776526	0,52993	0	28,08%		eventually more times
5		-0,403593386	-0,894418493	0,3164775	0,6899130	0,51979	1	23,06%		
6		0,485684378	0,913957040	0,4705664	0,6049775	0,52941	0	28,03%		
7		0,541286522	0,365831228	0,3947727	0,6037642	0,52468	1	22,59%		
8		0,660536968	0,25032142	0,5338039	0,4536699	0,53336	1	21,78%	(AK8-AL8)^2	
9	TEST RULE									
10		RANDBETWEEN(-1000000000;1000000000)/1000000000				1/(1+(EXP(-(AC9*W8+AD9*W9))))				
11			these weights should	1/(1+(EXP(-(H9*W2+I9*W3+J9*W4))))						
12			be adapted		1/(1+(EXP(-(H9*W5+I9*W6+J9*W7))))					

Fig. 156 ANN does not know anything yet; she has 25% chance to make mistakes

You have made Excel generate random numbers between 1 and -1 in column V and copied their *values* (not their formulas) as weights in column W.
Excel immediately starts generating new random numbers again so that they are no longer the same in ***Fig. 156***, but that does no longer play a role.

ANN has not yet learned anything with these random weights, and the number of errors coincides (MSE = 25%). Excel now can start *training* ANN.

You can train ANN

You ask Excel's solver to adjust ANN's weights so that her MSE (mean chance on errors) is as small as possible. On his menu you choose the possibility to minimize cell AN2 by adjusting W2 to W9 (the weights) with the evolutionary method. Once you have given that assignment, you see MSE drop to 0% after many rounds (***Fig. 157***).

The solver stops with the announcement that he has found a solution. If that is not less than 1%, then let him work again. The *training* is successful! Now you will *test* ANN.

	KLMNCPCRSTU	V	W	AC	AD	AK	AL	AM	AN	AO
1		copy as VALUES ->	weights	Hidden1	Hidden2	output	desire	error	MSE	
2		-0,863189410	-59,640409916	0,9997061	1,0000000	1,00000	1	0,00%	0,00%	SUM(AM2:AM8)/COUNTA(AM2:AM8)
3		-0,679462612	3,792799049	0,0007080	1,0000000	0,00000	0	0,00%	training succeeded!	
4		0,338076115	70,764977951	0,0000000	1,0000000	0,00000	0	0,00%		
5		-0,320147445	24,823910659	0,9650648	1,0000000	1,00000	1	0,00%		
6		-0,866879983	26,334807400	0,0000076	1,0000000	0,00000	0	0,00%		
7		0,477615253	-26,553737818	0,9997767	1,0000000	1,00000	1	0,00%		
8		0,375445642	66,86685797	0,9999964	0,9997101	1,00000	1	0,00%	(AK8-AL8)^2	
9	TEST RULE	0,033343660	-31,36994359	Test: copy the rule above		0,00000	<-yet false!	you judged too little profit (1)		
10		RANDBETWEEN(-1000000000;1000000000)/1000000000				1/(1+(EXP(-(AC9*W8+AD9*W9))))				
11			these weights give	1/(1+(EXP(-(H9*W2+I9*W3+J9*W4))))						
12			a good result		1/(1+(EXP(-(H9*W5+I9*W6+J9*W7))))					

Fig. 157 ANN has adjusted her weights; she can be tested assessing new patterns

You can test ANN

You copy the formulas AC8 into AC9, AD8 into AD9 and AK8 into AK9 (***Fig. 158***). Hidden 1, Hidden 2 and the Output neurons then display the data of that line in ***Fig. 155*** (H9, I9, J9) with new weights. ANN now gives the correct opinion about the unknown eighth pattern: 1 ('too little profit')!

	KLMNCPCRSTU	V	W	AC	AD	AK	AL	AM	AN	AO
1		copy as VALUES ->	weights	Hidden1	Hidden2	output	desire	error	MSE	
2		0,783705692	-59,640409916	0,9997061	1,0000000	1,00000	1	0,00%	0,00%	SUM(AM2:AM8)/COUNTA(AM2:AM8)
3		-0,907532463	3,792799049	0,0007080	1,0000000	0,00000	0	0,00%	training and test succeeded!	
4		0,756921663	70,764977951	0,0000000	1,0000000	0,00000	0	0,00%		
5		-0,832476586	24,823910659	0,9650648	1,0000000	1,00000	1	0,00%		
6		0,865998598	26,334807400	0,0000076	1,0000000	0,00000	0	0,00%		
7		-0,923172413	-26,553737818	0,9997767	1,0000000	1,00000	1	0,00%		
8		0,358947774	66,86685797	0,9999964	0,9997101	1,00000	1	0,00%	(AK8-AL8)^2	
9	TEST RULE	-0,874606373	-31,36994359	0,9999999	0,9999360	1,00000	<-right!	you judged too little profit (1)		
10		RANDBETWEEN(-1000000000;1000000000)/1000000000				1/(1+(EXP(-(AC9*W8+AD9*W9))))				
11			these weights give	1/(1+(EXP(-(H9*W2+I9*W3+J9*W4))))						
12			a good result		1/(1+(EXP(-(H9*W5+I9*W6+J9*W7))))					

Fig. 158 The judgment of ANN is consistent with the original judgment examples

The ANN detailed here is a simple example that you can expand with many more neurons: you can fill in the rows and columns of the input languages with much more

data. The instrument is numeric, but non-numerical data can be differentiated by numerical coding or given a separate column.
The 'desire' column can thus contain more values than 0 or 1 or be divided into more columns with more criteria ('this is an A', 'this is a B').

If the average error (MSE) is not small enough yet, you can extend the configuration with more hidden layers than Hidden1 and Hidden2 used here.
For different problems you can design different (consecutive, side by side, branched or circular) network configurations.

USUAL STATISTICAL METHODS ONLY RECOGNIZE WELL-KNOWN PATTERNS
What is the difference with statistical 'multivariate analysis' methods?
According to some statisticians, ANN offers nothing more than 'non-linear multivariate analysis' and 'discriminant analysis' that can also be performed with conventional statistical software.[a]

This is a one-sided vision from mainly numerical data analysis.
It reveals an extensive background of unspoken pattern-recognizing mathematical assumptions (graphs) among statisticians.

The regression patterns are limited in statistical practice to known mathematical functions (linear, exponential, polynomial, etc.). It was already difficult to come up with a job for the distribution of income in ***Fig. 117*** p147.

Then try to come up with a mathematical function that describes the character A.
An ANN does not have that restriction: every pattern can be recognized.

If you give an ANN thousand data sets (lines) of one hundred per line of data (columns), and you then tell her on each line whether the set is linear, exponential or polynomial (for example in the wish column coded as 1, ½, 0), then that ANN, after training, can recognize a subsequent data set in this way as such, even though there is no question of 'understanding'.

You can also use this method to recognize formulas such as $ax + b$, $ax^2 + bx + c$ and so on. That goes with their operation in the software of Excel all by itself, but to *make* that software a human neural network has been necessary.
In order to be able to make such curves in all their parametric variation and finally even make sense of them, another ability is needed.

This ability must not only be able to distinguish identifiable patterns that meet a 'desired' characteristic, but it can also dissect a pattern in detached properties (analysis and abstraction) that have not yet been named in columns (the input neurons).

We had pre-appointed the import categories and were then able to deduct the advertising (and all other costs) from the turnover to also name something as 'profit'.

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a Sarle(1994)Neural Networks and Statistical Models(SAS Users Group)Nineteenth Annual downloadable via http://www.sascommunity.org/seugi/SEUGI1994/Neural Networks and Statistical Models.pdf

This not only involves combining predetermined constituent data that makes a pattern recognizable, but also to analyze a given pattern and to make new patterns from those parts. 'Judgment ability' in the classical sense is attributing characteristics to existing parts and wholes and their distinctive or summarizing naming.

The creative ability to come up with patterns that do not yet exist as a whole or in parts (designs) goes even further.
I do not know if such ANN configurations can be thought of.
Perhaps the connections should be changeable. They are still stable in an ANN.

To make an ANN that knows and can do everything what a statistician or a normal person knows and can do, you will need innumerable neurons in different configurations for different tasks.

They are apparently spatially separated in the living neural networks.
Then you have to train and test that network. The latter may require a training that is just as long-lasting as what people need to come to the 'years of discernment'.

This upbringing now mainly consists of pre-saying and checking whether it is 'understood' (in the limited sense of 'usable for other wishes, in other situations, with different patterns').

The corrections in relation to a precooked list of 'good answers' are, in principle, still external. In evolution, the outside world is basically merciless: wrong is dead.
Foremost power is then a favor: first simulate, then do (self-correction).

Every success has to be remembered and can be called up for repetition with an unblocking stimulus in order to survive.

That course of action must descend into another configuration in the neural network as a routine that makes time-consuming simulations unnecessary in advance.
That makes the reaction speed competitive with a threat (eg fighting, approaching or fleeing). For unknown circumstances, the ability of representation remains.

In the described ANN, the import and its classification were precooked.
That applies also for an explanatory statistician, but for the reliable and valid handling of existing formulas, in addition to this description, a long-term training in mathematical foundations and their convincing evidence is assumed.

Those bases include a series of steps that suppose each other in a strict order.

All our actions (eg muscular movement), however, suppose (perhaps less strictly) such a series of preceding, learned, tacit, 'self-evident' routines, assumptions and representations.

Subsequently, if you detach all routine, ready to change usual suppositions then you keep the domain of designing: searching for possibilities that are not yet true or probable, and even not necessarily wanted by anyone.

§ 30 MATHEMATICS SUPPOSES A DESIGN

Fig. 7 p24 distinguishes modalities, levels of scale, context layers and object layers of design. Mathematics then exhibits the following design features.

Modality⇓((true⇒probable⇒possible⇒imaginable)∧desirable)
The modality of mathematical reasoning is supposed to be '**truth**'.
Anything true, however, must be probable, but not anything 'probable' is also 'true'.
Truth is a subset of **probability** (true⇒probable). This has some strange consequences.

'False' is usually taken as the denial of 'true' ('not true'), but 'improbable' is not a denial of 'probable'. It is only the 'lowest value' of probability (the zero-limit in ***Fig. 111*** p145). If truth is a subset of probability, then falsehood should also be the lowest value of truth and not its denial. Accepting 'values of truth', however, violates the usual logical bivalence of truth-values (excluding 'half-truth').

If truth is a subset of probability, then you cannot say “it is true that it is probable”, just as you cannot say “an animal is a cow”. You only can say “it is probable that is it is true”, just as you can say “a cow is an animal”.
'Probability' is then the prior modality of mathematical reasoning, however strange it may sound that 'one plus one is most probably two'.

It is less strange if you realize that any measurement or approximation of $\sqrt{2}$=1,41.. or π=3,14.. deviates from the 'real' value as an approximation.
The supposed exactness of equality and repetition of mathematics only exists in theory but not in reality, be it that the deviations are mainly too small to be of any practical importance. On the smallest level of quanta, however the uncertainty forces to calculate in probabilities.

The next modality boundary is '**possible**|impossible'.
Mathematical reasoning explores possibilities, even in the case of 'unlikely' low values of probability and even if they can only be imagined in a mathematical formulation.
Mathematics also exceeds the limits of the physically possible by allowing numerical values that are not or cannot be reached or measured.
Mathematics thus exceeds the limits of your **imagination**.

Mathematics creates conditions for earlier unimaginable representations (such as infinities of different sizes), but it only covers the possibilities that can be presented trough repetition and equality.
That is a network with gaps around the space of the imaginable.
It leaves the largest surface open in its meshes. It therefore cannot capture uniques without equality or repetition, no matter how small you make its meshwidth.[a]

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a That mesh size is reduced by expanding the set of functions. For example, Abramowitz; Stegun (1965) Handbook of Mathematical Functions (New York) Dover is an attempt to map 'all' known mathematical functions. This set of instruments can be extended infinitely, but the meshes remain.

You can only expect statements that something is very unlikely, but not that it is impossible. Mathematics itself does not make any pronouncements in the modality of **desirability**, before (outside mathematics) intentional qualities have been determined expressible in linear orderly values as numbers.

The mode of desirability defines the subsets (***Fig. 3*** p11): probable, but not desirable (problem field), desirable and probable (no problem), desirable and possible (aim field), desirable and not possible (forget it).

Levels of scale⇓(…,10m,3m,1m,…)
On page 20, scale levels are distinguished and named by a 'nominal radius' R, differing approximately with a factor 3, in order to avoid a scale paradox (***Fig. 6*** p18). Each level may be described by its own qualities (variables) and algorithms.[a]

For example, on a small scale a liquid has a mechanical order, but on a large scale a thermodynamic disorder.
Differences in class width in ***Fig. 117*** p147 or ***Fig. 131*** p154 can lead to different mathematical formulations and contrary conclusions.
The shape of large molecules is dominated by attractive and repulsive field forces at close range, but at other scales other forces dominate with different formulations.

Context layers⇓(Abiotics⇑Biotics⇑Technique⇑Economy⇑Culture⇑Governance)
Physics convinces with its predictive ability of **abiotics** mathematically, through the excess of repetition in its object. Yet doubt remains justified.

Einstein also felt a necessity to make explicit once more his generally shared assumption that mathematically sound mechanics apply everywhere.[b]
The variable context of lapsing fields in the universe does not exclude unknown, unpredictable fields, effects and singularities.

Biotics and its organic chemistry is less endowed with repetitive phenomena.
The diversity of its object is unimaginable. Unpredictable singular mutations, for example, do not make possible to model evolution itself and to predict its course.

Life forms are context-sensitive and more changeable, more adaptive than dead matter. They always deviate in detail from deterministic-fractal iterations.
Organisms reproduce regularly, but not in exact repetition.

Minor deviations may have major consequences. Organisms react passively and actively to their environment ('adaptation' and 'accommodation').

Yet repetition is also abundant in biology and then mathematically accessible.
The physical context already provides repetitions. Day and night, seasons and longer periods alternate. Chemical cycles endlessly repeat themselves in every cell.

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[a] Jong(2012)Diversifying environments through design(Delft)TUD thesis

[b] Einstein(1916)Die Grundlage der allgemeinen Relativitätstheorie(Annalen der Physik)IV 49 p769-822op p770: 'Wird ein Koordinatensystem K so gewählt, daß in bezug auf dasselbe die physikalischen Gesetze in ihrer einfachsten Form gelten, so gelten dieselben Gesetze auch in bezug auf jedes andere Koordinatensystem K', das relativ zu K in gleichförmiger Translationsbewegung begriffen ist.'

Any mathematical reduction can be refined with additional variables and operations. There is then a moment when models get an uncontrollable size and complexity in order to approach the living reality. For example, if it is ever possible to model a person, then still all people are different. Next, millions of other species have to be modeled with a multitude of ecological relationships

Products of **technique** are comparable with machineries known from biology. Their effect is less refined, but their global effect is the greater. The *design* brings variation, but *mass production* of artefacts is a matter of large-scale repetition.

So, mathematics has an important dual role in technology.
It makes possible to reduce and handle repetitions in design *and* in production.

It plays that role less dominantly in **economy**, the game of demand and supply, of production and consumption. Nevertheless, the business cycle remains unpredictable. That is even more the case with **culture**. In addition to repetitive tradition, culture includes experimental varying search for possibilities, *designing*.

The modality of the desirable is paramount in **governance**.
In that modality itself, mathematics can contribute little, but the sociological, economic, technical, biological and physical substantiation of desirability ('optimization') is full of mathematical applications.

From that modality, however, it must obtain its input: variables that can be expressed in linearly orderly values and permitted operations.

Object layers ⇓ (Content ⇑ Form ⇑ Structure ⇑ Function ⇑ Intention)
In mathematics, the variables are its **content**. Its **form** is a linear verbal language. The operators are the connecting (for example adding) and separating (for instance subtracting) components of its **structure** (the 'algorithm'). Its **function** is the outcome and its **intention** the reduction of repetition

Structure ⇓ a spatial placement, a distribution of its components and that **form** in turn ⇓ a material (the **content**) that can take that form. These are design dimensions that have to be subjected to mathematical evaluation, but in themselves require little mathematical support. Geometry, graph theory or topology can help, but intuitive compositional design skills are more flexible and mainly sufficient.

MATHEMATICS CAN BE CONSTITUTED

Is mathematics constitutable according to ***Fig. 13*** on p37? It reads:

A difference ⇈ change ⇈ coherence ⇈ selection ⇈ combination ⇈
B metabolism ⇈ regulation ⇈ organization ⇈ specialization ⇈ reproduction ⇈
C information ⇈ security ⇈ affection ⇈ identity ⇈ influence

Mathematics supposes a **difference** of variables mutually, but an absolute equality ('zero difference') within each variable (units and intervals determining the values). **Change** is a kind of difference. So, without explicitly mentioned directions (vectors) or causality (functions f(x)), the direction of time is still reversible.

The **coherence** is symbolized by the '=' sign. The **selection** of variables at both sides supposes coherence (units). Then, these variables can be **combined** by operations symbolized by signs such as +, -, *, / etc.

Different combinations may produce the same output.
That enables a kind of **metabolism**, entering the technique of the biotic layer.
Changing that metabolism enables **regulation** by parameters.

An **organization** (organ) adapts its functioning by coherent regulation. Selection of an organization enables **specialisation** for a special task (applied mathematics).
Combining specialisations produce a system (organism) that may be **reproduced**.

It can be reproduced in a report as **information** for **security**. A patent or copy right connects that algorithm to an **identifiable** owner with **affection** for her or his creation.
That is why the name of **influential** mathematicians still are connected with groundbreaking recipes in mathematics. Honor where honor is due.

This very short constitution of mathematics may require some explanation.
The words used beyond the abiotic layer may seem far-fetched, but the sequence is more important than the picket posts, hiding abstractions missing covering words.
There is always reason to change the *terms* of ***Fig. 13*** on p37, but not its *sequence*.

MATHEMATICS REDUCES QUALITY TO QUANTITY

Mathematics *reduces* the subjects and direct objects of verbal language to quantities, named by numbers. It reduces its verbs to a limited set of operators.

It *extends* our limited imagination of repetition (eg the possibility of infinitely repeated operations, yet resulting in one image or one imaginable quantity).
All examples of mathematics in § 25-§ 29 show repeating quantities and operations.

Counting *repeats* adding a unit until a quantity is covered, naming the steps (1, 2, …).
Operations repeat, or are repeated (eg multplying $3*2=2+2+2$ or squaring $3^2=3*3$).
A 'number' records the result of repetitions, hiding the separate operations.[a]

In order to distinguish the specific *roles* of quantities in the context of operators, whatever value they may have, Descartes (p95) proposed to give different quantities

a With 'numbering' (not yet counting) you only give elements their own name ('index'). It distinguishes 'equal' objects that only 'differ from place'.

different symbols (eg x and y supposing an independent and a dependent role).
This *external difference* implies (p16) *internal equality* of type[a] (including its units).

That difference is supposed, even if the calculation contains only one type of variable. Geometry takes 'length' as a primary variable, but it distinguishes lengths on different locations and in different directions as *different variables*.

The 'opposite side' of a right-angled triangle differs from the 'adjacent side'.
Their lengths are of a different type, a different 'quality'.
They even get different units, if the triangle moves into a different coordinate system.

The proper distinction of variables and their role in calculations is an act of *design* in mathematics. Descartes distinguished x and y coordinates within the common perception of 'location', inventing the beginning of linear algebra.
Newton distinguished 'mass' and 'force' within the common perception of 'weight'.

Design invents a *difference*. Applying mathematics discovers *equality*.

Quality may have no sequential order
Place and size are distinctive qualities of an object, expressible in numbers.

If an isolable characteristic of the objects in a set has sequential variants (of color, price, intelligence), then such a quality can be expressed in numbers.
A quantified quality may require more than one number summarized in a vector, matrix or tensor.

A 'number', however, is first and foremost the result of counting: an action, a repeated adaptation of, or building upon, a previous result (iteration, p150).[b]
Iteration is part of every human activity, of every subactivity that repeats itself over time until the next routine. The 'time' then forces a sequential order.[c]

This supposes a starting point as the beginning of action.
In counting, this is a 'zero point' or with other iterations a random number or in geometry a 'fixed point' and a 'direction'.

If a number can change or if its value is not yet known, then there is still a nameable quality (a variable, eg x or y). The name can represent the summary of different qualities, but as a 'variable' it is reduced to a *linear, sequential* representation, a single 'number' supposing a zero point, a unit of 'value' and a sequence of values.

That is also an important reduction.
If this generalization does not suffice, then you must distinguish (by analysis and abstraction) partial qualities in that set and give them their own name (variable).

---

a Ryle's requirement of equal 'type' in note a on p35. 'Redder than round' makes no sense. You cannot compare different types. I will speak of the 'quality' of such a type: 'the attributes by which you can distinguish an object from other objects', such as 'colour' *or* 'form'.

b Moreover, this supposes again that what is counted differs from 'place' (to avoid double counting), but is otherwise 'equal', has 'the same' quality (for example 'x'), belongs to the same 'set' (not to 'y'). Even if the values of x and y overlap, they are different sets that (with a dubious term) can be 'imaged' on each other, complete or incomplete ('bijective').

c Building is impossible if you cannot 'build on' a previous result. A foundation can be difficult to replace also in an abstract sense.

Each component then has its own linear and sequential representation, so that the mathematical editing has to be revised and given a more complicated form.

This process can be repeated if further distinction proves to be necessary.
However, if 'everything differs', then mathematics would drown in as many variables as there are differences.

The unique contradicts repetition
Mathematics assigns a distinctive 'quality' (see p64) of separate objects to a set.
This set *differs externally* from other sets supposing an *internal equality*.

These objects, however, may still differ in many other respects (not provided in the criterion of the set)[a], and in any case due to difference in *place* and thus environment.[b]
Counting such a heterogeneous set then may be problematic.

For example: take counting 'people' as a heterogeneous set.
The definition of what exactly is a 'human', meets insurmountable problems.
In any list of characteristics, you may include features that we cannot consider as typically human for everybody.

There are people without arms or legs. Such characteristics in the definition then should be omitted, but there are ever more 'defects' that need to be omitted from the definition until no one can be counted as human anymore.

Probability calculation on such heterogeneous sets leads to unilateral (eg epidemiological) conclusions with potentially serious bias.

From a sample of n people with a certain disease, you can determine the chance of recovery by a medication 'double blind'.[c]
The chance of side effects 's' (s_1/n, s_2/n and so on) can be established only if the chance is substantially greater than $1/n$. Other side effects remain out of the picture.

People react differently to medicines. The amount of different side effects s may be larger than n, theoretically even larger than the total amount of people (>7 billion!).

The unique patient can therefore not prove by statistics (for one case, as the pharmaceutical industry does for specific recovery at n cases) that her or his rare, not repeating new disease was caused by a previous medicine.

This is a fundamental methodological one-sidedness of the one versus the majority.

a See the motto of this study opposite of p1 from Descartes(1684)Regulae ad directionem ingenii; Regulen van de bestieringe des verstants(Den Haag 1966)Nijhoff: 'People have the habit, as soon as they recognize any equality between two things, to presume that equality in everything in which those things differ'.
b That place (including time) is considered as a 'quality' of an object seems strange, but it is a crucial 'characteristic with which you can distinguish an object from other objects'. Difference of place, for example, is necessary to prevent double counting. Exactly the same house may be worth more here than there.
c Half of the sample is given a placebo.

7 MATHEMATICS SUPPOSES REPETITION

MATHEMATICS EXTENDS IMAGINATION

Mathematics extends verbal language by reduction

If x and y are reduced to numbers, then you may reformulate y(x) as x(y).
In common language, however, such a reversal violates the tacitly supposed causal sequence of an active subject affecting an object: object(subject).
Common language supposes one direction and a sequential (causal) order.

In 'egg(chicken$_1$)' and then 'chicken$_2$(egg)', there are two different chickens.
Its logic is bio-logic, forcing to include uncountable many intermediate variables.
From building(builder) you cannot even derive builder(building), unless in a cultural sense. Its logic then is anthropo-logic, with even more variables.

Repeated adding (counting up) can be reversed into repeated subtracting (counting down) in the opposite direction. Continuing that action may result in negative quantities, hardly imaginable other than 'shortage'.
A shortage, however, cannot be multiplied by itself in order to get a surplus.

Common language cannot cope with different directions without referring to an image. It hardly can cope with two opposite directions (one 'dimension'), eg 'future' and 'past' in time (the tacitly supposed direction in common language).

Graphs that show two quantities ⊥ to each other are able to visualize different directions and negative quantities, but this way of representation portrays relations of variables which do not have to be ⊥ in reality.
They may not even have an angle, as they do indeed in geometry.

Adding and subtracting quantities in more directions than two opposite ones, requires reduction to numbers with different quality (the vectors of ***Fig. 65*** p129126).

Linear algebra then provides a technique that can produce multidimensional representations. It escapes linear language by matrices and tensors. It distinguishes the different quality of each quantity, giving each variable its own dimension (eg x, y, z).

Extending this technique goes beyond the observable space-time.
It may extend your imagination, but the image remains limited by the reduction of qualities into numbers and repetitive operations.

8. ABIOTIC CONDITIONS ARE PROBABLE

8 Abiotic conditions are probable

§ 31 Relative movement is the core of physics

Gravity attracts, electric charge attracts *and* repels

Classical mechanics since Newton[a] reads (with *units*, without derivatives):

Velocity 'v' is a traveled distance 's' divided by the required time 't'(*m/sec*):	**v=s/t**
Acceleration 'a' is v, again divided by the time t, in order to reach that speed (*m/sec²*):	**$a=s/t^2$**
Force 'F' is the acceleration 'a', times the accelerated mass 'm' (*kg∗m/sec²*, *newton, N*):	**F=m∗a**
Energy[b] 'E'[c] is a force F exerted on a mass m over a distance s (*joule, J*):	**$E=m*v^2$**

Two masses of 1*kg* (m_1 and m_2) with s=1*meter* distance between their centers of gravity attract each other by approximately 0.0000000000667428*newton* (*N*).
That number ($6.67428 * 10^{-11}$) is usually abbreviated as G in Newton's gravity formula[d]: $F = G*m_1*m_2/s^2$. It describes the mutual gravity force F of any pair of masses m_1, m_2 at any distance s between their centers of gravity.
It is larger with greater masses m_1 or m_2 and at a *smaller* distance s.

For example, the Earth ($m_1=5.97\times10^{24}$ *kg*) and I ($m_2=75$*kg*), attract each other at a distance s= 6371*km* (the Earth's radius) with $F=G*m_1*m_2/s^2=735.15$*newton*.
If I jump from a springboard, then the Earth gets a negligible acceleration $a=735.15/5.97*10^{24}=0.000000000000000000000123$*meters/sec²*, but my much smaller mass is set in motion with an acceleration a=F/m=735.15/75=9.8 (*m/sec²*).

Similar to Newton's gravitational formula, Coulomb (1785)[e] found that two opposite (+ and -) *electric charges* Q_1 and Q_2 attract each other also with a force proportional to the product of both (but absolute, without minus signs: $|Q_1|$ and $|Q_2|$), divided by s^2.
This resulted in the analogous 'Coulomb's Law': $F=k*|Q_1|*|Q_2|/s^2$, where $k\approx9*10^9$ in vacuum.[f] If both charges are positive (or negative), this also applies to their mutually *repelling* force.

Electric charge is a different number of electrons and protons

The smallest charge is the 'elemental charge' of an electron (-) or proton (+).
If you would interprete an electron as a small body, then two contiguous electrons may *attract* each other by *gravity* with $F=G*m_1*m_2/s^2\approx7*10^{-42}N$ force, but their *charge repels* them with a force of no less than $F=k*|Q_1|*|Q_2|/s^2\approx7N$[g].
So, in this case the force of gravity is insignificant compared to that of charge.

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a Newton(1687)Philosophiae naturalis principia Mathematica(London) or Newton(1687)The Principia: Mathematical Principles of Natural Philosophy. Preceded by A Guide to Newton's Principia, by I. Bernard Cohen(Berkeley 1999)University of California Press ISBN 0-520-08816-6 ISBN 0-520-08817-4 originally Newton(1687)Philosophiae naturalis principia Mathematica(London)

b If you add up all indivisible small velocities dv from 0 to the final velocity v_e, and you multiply that with the m of one moved mass: $\int_0^{v_e} mv \cdot dv = \frac{1}{2} m{v_e}^2$, then you have calculated the kinetic energy E of that mass m with speed v_e. However, if you push a car to that speed, then the ground surface also undergoes the same force in the opposite direction. This must bring about an immeasurably small movement of the earth 'at rest'. That 'reaction mass' then receives the same kinetic energy in opposite direction. That work $W=½ mv^2$ is another part of your work, in total $E=mv^2$.

c In this section I will use and add units in *italics*. E with its unit E(*J*) then is distinguished from a symbol for electric field strength E(*N/C*).

d Newton(1687) Proposition 75, statement 35: p.956

e Coulomb(1785) Second mémoire sur l'électricité et le magnétisme (Histoire de l'Académie Royale des Sciences) p578-611, p597

f For those who want to know exactly: the 'Coulomb's constant' $k = 8.9875517873681764*10^9 N*m^2/C^2$.

g For the mutual center of gravity between connected electrons I have assumed $s\approx5,6*10^{-15}$ *meters*. So, $1/s^2=3,1*10^{28}$.
As a result, $F\approx9*10^9*|1,6*10^{-19}|*|1,6*10^{-19}|*3,1*10^{28}\approx7N$ becomes so large.

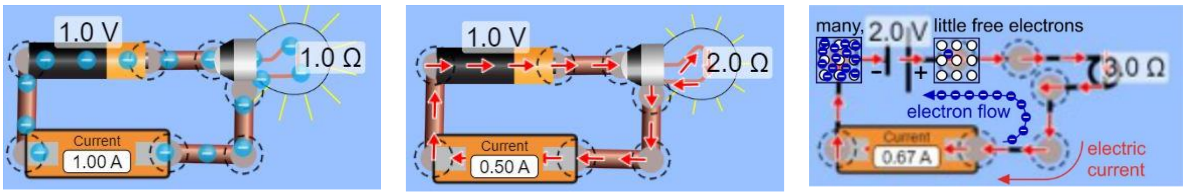
Positively charged protons in the nucleus of an atom attract the surrounding *negative* electrons by their charge, but these are kept at a distance by their centrifugal force. That is also an indication of their speed.
Within the nucleus, two equally +protons *repel* each other with a comparable force, but at such a short distance, this again is completely inferior to a third 'fundamental natural force': the 'strong nuclear force'. For that force you should not divide by s^2, but by s^7, increasing the force substantially. It prevents the nucleus from exploding.[a]

A coulomb (*C*) is the charge unit of 6241509074460762607.776 ($\approx 6.24 * 10^{18}$) electrons. At 1 meter, two charges Q of 1*C* repel each other with $F = k \approx 9 * 10^9$ *newton*! So, 1*C* is a large charge with very large power.
I will therefore also calculate easier with picocoulombs *pC* (1*pC*=10^{-12}*C*).

ELECTRIC CURRENT DISPERSES CONCENTRATED ELECTRONS

This brings us back to the scale of our daily use of electric *current*.
That is the number of coulombs flowing per second (ampere, *A=C/sec*) through an electric wire. That current is created by a 'voltage', the potential energy between both ends of an electric wire (expressed in volts *V=J/C*,), but the wire obstructs more or less the flow with a resistance expressed in ohms, *Ω*.

These *units* are related as *V=A*∗*Ω*. Their *quantity* U provides Ohm's law[b]: $U = I * R$ (the voltage U in *volts V*, the current I in *amperes* A, and the resistance R in *ohms Ω*).
Fig. 159 is an example of Ohm's law in a flashlight, with increasing resistance R(*Ω*) and different values for U(*V*) and I(*A*), all of which correspond to this law.



1*V*=1*A*∗1*Ω* 1*V*=0,5*A*∗2*Ω* With the usual symbols: 2*V*=0,67*A*∗3*Ω*

Fig. 159 Ohm's law in the circuit of a flashlight[c]

The current direction as shown traditionally in electrical circuit diagrams is opposite (different from initially supposed) to the direction in which the electrons actually flow (counterclockwise in the last ***Fig. 163*** p179). So, '+' indicates an electron shortage.

The resistance R(*Ω*) differs per material and temperature.
For example, the 'resistivity' of copper at 20°*C* is $1,7 * 10^{-8}$ *Ω*∗*m*²/*m*.
So, a copper wire of 1*m* with an intersection of 10^{-6}*m*² (1*mm*²) has a resistance R=resistivity∗length/diameter=$1.7 * 10^{-2}$=0.017*Ω*.

---

a I will not consider a fourth natural force ('weak nuclear force'). See https://en.wikipedia.org/wiki/Fundamental_interaction
b Ohm(1827)Die galvanische Kette(Berlin)Riemann https://web.archive.org/web /20060619102047/http://www.mb.fh-nuernberg.de/bib/textarchiv/Ohm.Die_galvanische_Kette.pdf p178
c https://phet.colorado.edu/nl/simulation/circuit-construction-kit-dc

My low-voltage light bulb measures 2Ω. A wire to cut styrofoam should not glow. It has to become less hot, but over a longer distance.
You then have to buy 'resistance wire' of 5.65 *Ω* per *meter* at 20^o*C*. That is 1.13Ω for 20*cm*, but that temperature-sensitive resistance will rise into 1.5Ω at 1000^o*C*.

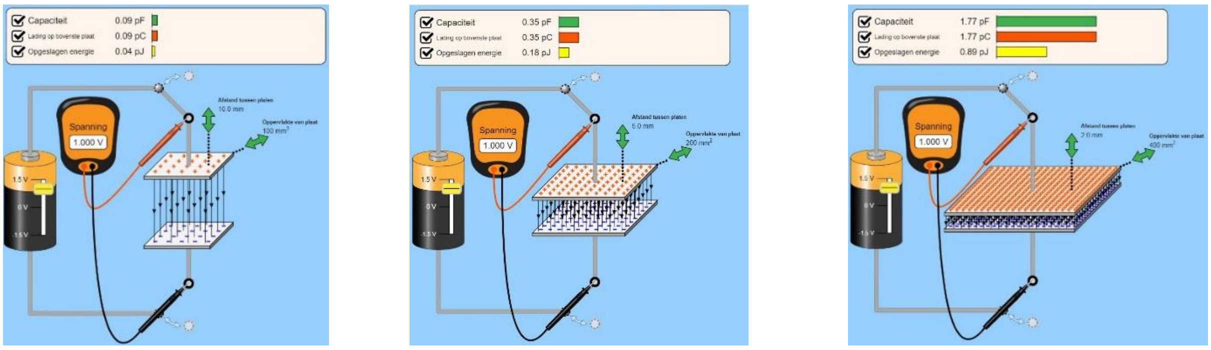
ELECTRIC ENERGY CAN BE STORED

The flashlight radiates two forms of energy: light and heat. Energy per second is called 'power' P (expressed in *watts*, *W*). In a circuit P(*watts*)=U(*volts*)*I (*amps*). (Remember it as '*Wa* is *VA*'.) A person at rest uses about 100*watts*, but running 12*km/hour* takes 1000*watts* (1*kilowatt*, *kW*). If you keep that up for an hour, then you have used 1 *kilowatt-hour* (*kWh*). That is 1000*60*60 '*wattseconds*'.

So, one wattsecond (*W*sec=J*) is not power, but (during a *second*) energy, E(*J*). Lighting a 1watt LED during a year costs a wattyear: 365*24*60*60=31 536 000J. This happens to be almost equal to the energy content of a m^3 natural gas, a *kilogramme* of coal or a *liter* of petrol.

The lamp uses energy from the battery. A battery produces and keeps its voltage by chemical means[a], but its performance can be compared to that of a 'capacitor'.
A capacitor keeps a voltage between two separate, differently charged plates, because the plus charge of one plate attracts the minus charge of the other with the forementioned Coulomb force $F=k*|Q_1|*|Q_2|/s^2$.

If you put two plates of 1*1*cm* (surface $A=0.0001m^2$) at 1*cm* distance (s=0.01*m*) under 1*volt* (***Fig. 160*** p180), then the 'capacitance' of the capacitor is: ε*A/s=0.09*pF* [b], where ε is the 'permittivity'[c] of the medium between the plates. If you multiply that capacitance ε*A/s by U(*volt*), then you know also the charge Q=ε*A*U/s=0.09*U(*pC*).



A=0,0001m^2, s=0,01*m*, U=1*V* A=0,0002m^2, s=0,005m, U=*1V* A=0,0004m^2, s=0,002*m*, U=*1V*

Fig. 160 A capacitor stores the applied voltage, affected by surface and distance[d]

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a https://nl.wikipedia.org/wiki/Batterij_(elektrisch)
b The unit of capacitance is farad (*F=C/V*), but 1F is a very large capacitance, so I will continue using picofarad=$pF=10^{-12}F$.
c The "permittivity" $\varepsilon=\varepsilon_0*\varepsilon_r$ determines the degree to which not the electric current, but electromagnetic force is transmitted.
In this, ε_0=8.854187818*10-12(*C2/N*m²)*, the 'electric field constant under vacuum' is a nature constant. If the space between the plates is filled with material ('dielectric' medium), for example air, then ε_0 must be multiplied by a factor ε_r ('relative electric field constant'). That is a factor specific to each material. For example, for air it is 1,00056, but for water 78.50.
We now can also calculate the "constant" of Coulomb k better as $1/(4*\pi*\varepsilon)=8.9876*10^9(N*m^2/C^2)$, where π ('pi') = 3.141592654.
d https://phet.colorado.edu/sims/html/capacitor-lab-basics/latest/capacitor-lab-basics_nl.html

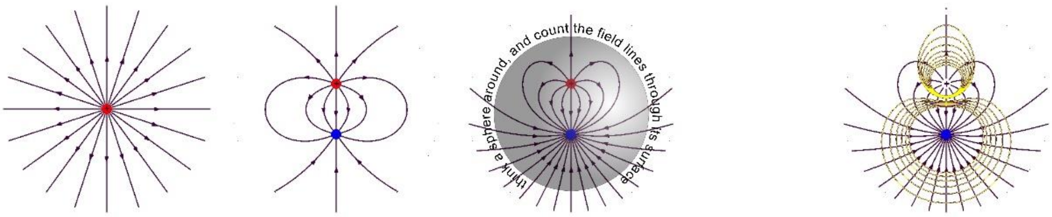
With the charge Q and the voltage U, then you know also the stored energy: E=Q*U/2=0.04 (*pJ*).[a] So, this *energy storage* of the capacitor E=Q*U/2=0.04 (*pJ*) is something else than its *capacitance* ε*A/s=0.09(*pF*).

With Q you can now also *calculate* the attractive force between the plates: $F=k*Q*Q/s^2=0.73$ (*pN*). This force increases when the distance s in the denominator decreases (see the third figure) so that more electrons are attracted on one plate. This also applies if the area A of the plates increases. Then you can of course also hold more electrons. In both cases, the capacity increases and so does the charge Q(=capacity*voltage U) and the energy storage W(=Q*U/2).

AN ELECTRIC FIELD ⊥ MAGNETIC FIELD

Between the plates there is a 'homogeneous' *electric* force *field* E_F=F/Q that draws every stray electron to the *plus* plate with *less* free electrons. The strength E_F can be visualized with a corresponding number of field lines, albeit reduced by the extent to which electric force is transmitted in the medium (/ε).The density of lines (if they are well drawn) indicates the field strength E_F in newtons per coulomb, F/Q(*N/C*).

Without plates, such an electric field also exists around one ore more points of charge (***Fig. 161***), but that field is 'heterogeneous' (not homogeneous).
Within the resulting field of more charge points, smaller charges have less influence.



A point charge, two equal opposite, a smaller +charge. The ⊥ magnetic field added

Fig. 161 Electric fields and perpendicular* (⊥) *on these a magnetic field[b]

With more point charges you should think a sphere or any closed surface around it. The volume of a sphere is $4*\pi*r^3/3$ and its surface $4*\pi*r^2$. Q/volume is called 'charge density' ρ, the number of field lines through a closed surface is called 'flux' Θ(*V*m*).[c]

MOVEMENT INDUCES FIELDS AND CURRENTS

If from some point of view a charge *moves* (for example within an electric wire), then ⊥ its *electric* field lines develops a *magnetic* field (the last ***Fig. 161*** p181).
But moving with the charge yourself, you would not experience a magnetic force.

Faraday(1831) showed the effect of 'electromagnetic induction'[d]. He invented an instrument with a bar magnet rotating around a current-conducting wire along these

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a For the capacitance, except ε you only need to know surface/distance A/s. If you, however, already knew the charge Q and voltage U, then also capacitance =charge/voltage=Q/U. You can see this relationship in its own unit *F=coulomb/volt=C/V*. The charge Q is derived from the sum of each dq growth of a charge q counting from 0 to Q ($\int_0^Q q\,dq=Q^2/2$). Divide that by the capacitance Q/U and you get the work W=E/2=Q*U/2.

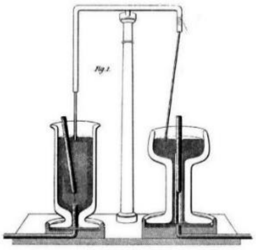
b http://home.kpn.nl/H.Bruning/applets/e-veld/e-veld.htm

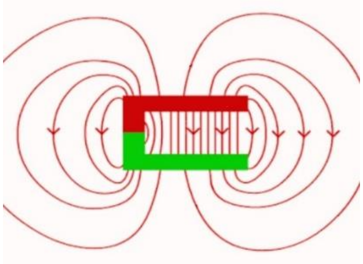
c The famous 'Gauss's Law' (1813) states in total Θ=Q/ε.

d This is beautifully demonstrated in http://home.kpn.nl/H.Bruning/applets/inductie/inductie.htm.

lines (the first ***Fig. 162***), and vice versa: a current-conducting wire rotating (keeping its current through mercury) around a magnet. He invented the first 'electric motor'!

A current-conducting wire in the homogeneous magnetic field within a horseshoe magnet (the last ***Fig. 162***) is pushed away ⊥ to its field lines and it is attracted when the current direction is reversed at the right time. A more developed electric motor (***Fig. 163***) allows that to happen on a spinning axis that simultaneously reverses the electric flow direction in time in order to change the push into pull (and the reverse).





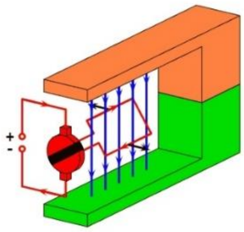
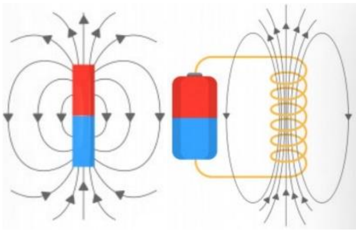


Fig. 162 Faraday's motor(1821)[a] ***A horseshoe magnet***[b] ***The principle of an electric motor***[c]

A stationary magnet has a permanent magnetic field, but an electromagnet can reverse its polarity.



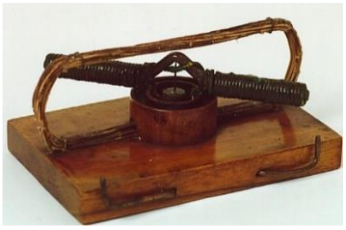


Fig. 163 Stationary, electric[d] ***Jedlik's motor(1828)***[e] ***An electric motor***[f]

Periodically pushing and pulling by changing the polarity enhances the effect of the power wire between the poles of a stationary horseshoe magnet.
In order to *generate* electricity, a dynamo[g] follows the opposite principle.
Electric current cannot only be converted into mechanical work, but also vice versa.

If a charge Q=1*C* moving with speed v=1*m/sec* ⊥ through a magnetic field, with strength $B= F_B/Q*v$ or $F_B/I*s$, experiences a force F_B=1*N*, then B=1*tesla* or 1*T* (*N*∗*sec*/*C*∗*m*). Magnets in a loudspeaker may have a rather high field strength of 0.2*T*. So, the force $F_B=B*I*s$ on a charge conducting wire increases with the field strength B(*T*), the current I(*A*) and the part of the wire s(*m*) exposed to the external field.

a Faraday(1844)Experimental researches in electricity II(London)Taylor Plate IV
b https://sites.google.com/site/elektriciteit1/inhoud/het-magnetisch-veld?tmpl=%2Fsystem%2Fapp%2Ftemplates%2Fprint%2F&showPrintDialog=1
c http://home.kpn.nl/H.Bruning/applets/elektromotor/elektromotor.htm
d https---nl.freepik.com-premium-vector-natuurkunde-wetenschap-over-de-beweging-van-magnetische-velden_4010627.htm
e https://commons.wikimedia.org/w/index.php?curid=7868302
f A pre-war Trix toy engine, see https://www.pa3esy.nl/zelfbouw/trix/html/trix_set.html
g The old name "dynamo" has been replaced by "direct current generator" or "communator", in order to distinguish it from an "alternator" that generates alternating current. Both are then "electric generators".

Winding a wire n times on a electrical steel bar, extends s into n∗s ⊥ the bar. So, if the bar is // (parallel) to external field lines, then the wire is ⊥ to them. The smaller the length l of the bar, the larger appears its winding density and thus its magnetic field strength: B=4000∗n/l. The factor 4000 ('relative permeability' μ_r)[a] only applies if the wire is wound around a electrical steel core. So, an electric motor should have as many winding turns n as possible at the shortest possible length l.

The field lines *outside* a magnet disperse (no longer homogeneous, but heterogeneous), returning and concentrating into the other pole without beginning or end. The electric field of the wire (largely neutralised in a winded form) has little impact. An electric motor then uses the internal and static external *magnetic* fields only.

The *electric* field strength E_F already exists with any stationary charge: $E_F=F_B/Q$. Any charge will experience that force. 'Equipotential' lines ⊥ the electric ones (the magnetic lines), connect points with the same *potential* energy. *Crossing* them you may experience the differences in voltage, expressible in volts per meter *V/m=N/C*.

WALKING THROUGH THE FIELDS CHARGE YOU

Crossing ⊥ *magnetic* field lines means following an *electric* field line 'upwards' into the radiating charge or 'downwards'. The voltage you loose downwards at each indivisible point (derivative) is the local charge density ρ of the passed equipotential line, divided by the permittivity of the medium ε.[b] If you are charged yourself also, then you will experience the forementioned Coulomb's force $F=k*|Q_1|*|Q_2|/s^2$.

If you pass the electric field lines ⊥ without any deviation, then you walk along a line of the equipotential *magnetic* field without a change of voltage, but if you are magnetic, then you will experience a force $F_B=B*Q*v$, dependent on your *speed* v relative to the external field B![c] If you move with the same speed as B, then $F_B=0$.

An *electric* field force F_E *on a particle*, however, *does* deviate ⊥ indeed by a *magnetic* force F_B. The three-dimensional 'resultant'[d] $\mathbf{F}_E+\mathbf{F}_B$ is called 'Lorentz force' $\mathbf{F}_L$.[e] Vectorial addition ('+') requires formulation of their local field forces in terms of **vectors**: $\mathbf{F}_E=Q*\mathbf{E}_F$ and $\mathbf{F}_B=Q*(\mathbf{v}\times\mathbf{B})$. So, $\mathbf{F}_L=Q*(\mathbf{E}_F+\mathbf{v}\times\mathbf{B})$.[f] Notice again that in the *magnetic* force $\mathbf{F}_B$ the *speed* **v** plays a role, but not in the *electrical* force $\mathbf{F}_E$.

The mathematical representation of *curved* lines (as it is the case in a force field $\mathbf{E}_F$ and **B)**, requires their differentiation into each indivisible point of the line in three dimensions [dx, dy, dz]: $\mathbf{E}_F/dx+\mathbf{E}_F/dy+\mathbf{E}_F/dz$ and $\mathbf{B}/dx+\mathbf{B}/dy+\mathbf{B}/dz$, briefly represented with the 'nabla-operator' ∇ as $\nabla\cdot\mathbf{E}_F$ and $\nabla\cdot\mathbf{B}$, respectively.

a See https://en.wikipedia.org/wiki/Permeability_(electromagnetism)
b Gauss's law (1813) and Maxwell's first equation (1865).
c This is simulated nicely in http://home.kpn.nl/H.Bruning/applets/inductie/inductie.htm
d The 'resultant' is a vector sum (a diagonal in the parallelogram of vectors). A vector is a number with a direction, further shown in bold. For vectors, '+' means a "vectorial addition". The sign '×' is the 'cross-product' between both direction-bearing vectors v and B. It is the matrix operation that formulates the difference of perpendicular (⊥) direction between the two. See p108.
e This is simulated nicely in http://home.kpn.nl/H.Bruning/applets/lorentzkracht-afbuigen/lorentzkracht-afbuigen.htm
f https://nl.wikipedia.org/wiki/Lorentzkracht

A SUMMARY OF ELECTROMAGNETISM TAKES 4 EQUATIONS

Maxwell (1865)[a] summarized the essentials of electromagnetism in 20 equations with an important addition. Heaviside (1884) reduced this to 4 equations:[b]

1 $\nabla\cdot\mathbf{E_F} = \rho/\varepsilon$ (Gauss, 1813) You will loose or gain ρ/ε voltage on each step.
2 $\nabla\cdot\mathbf{B} = 0$ (Gauss, 1813) In the magnetic field you have equal velocities back and forth.
3 $\nabla\times\mathbf{E_F} = -\partial\mathbf{B}/\partial t$[c] (Faraday,1831) $\mathbf{E_F}$ changes when **B** *moves* $\perp\mathbf{E}_F$ or $\times\mathbf{E}_F$ ('induction').
4 $\nabla\times\mathbf{B} = \mu*\rho*\mathbf{v} + \mu*\varepsilon*\partial\mathbf{E_F}/\partial t$ (Ampère, 1826, + Maxwell, 1865) **B** changes $\perp$ proportional to the current permeability μ, charge density ρ and its own *velocity* **v** + (Maxwell) with every *change* of the electric field $\mathbf{E_F}$ times μ and the permittivity ε.

These equations are understood as the most brilliant summary of everything concerning electromagnetic effects. How, however, could you understand the role of *movement* within these effects, changing time **t** and distance **s** between the objects simultaneously if velocity **v**=d**s**/d**t**?

Einstein(1905) wrote a study 'About the electrodynamics of moving bodies', better known as 'Special theory of relativity', proving that in Newton's mechanics time **t** and distance **s** themselves change in and between bodies differently moving.
A *magnetic* field of one body then appears as an *electric* field for the other one.

a Maxwell(1865)A Dynamical Theory of the Electromagnetic Field(PhilTransRSocLondon)155 459-512
b https://en.wikipedia.org/wiki/Maxwell%27s_equations, https://www.nemokennislink.nl/publicaties/james-clerk-maxwell-de-onopvallende/
c dB/dt, would deduce all variables in B=Fb/(Q*v) into t, but ∂B/∂t is a 'partial derivative', keeping any variable constant except speed v.

§ 32 MECHANICS RELATIVATES SPACE AND TIME

Mechanics creates a deterministic worldview. This makes the world in principle predictable as a calculable process from the Big Bang onwards if you would know exacly all of its initial values. The mechanics of Newton seemed to be a complete whole until Einstein put them into a relativistic, but also deterministic perspective.[a]

Half a century before Einstein, a more statistical approach in thermodynamics had already proven to be necessary. It worked reasonably well to bring both approaches into line with each other on different levels of scale.[b] With the rise of quantum physics, however, this again became a problem on an even smaller scale.

E=MC² IS THE LIMIT OF E=MV² DUE TO THE MAXIMUM SPEED OF MASSES C

Remember the classical mechanics since Newton[c] (p178, without units):

Velocity v is a traveled distance s divided by the required time t:	**v=s/t**
Acceleration a is v, again divided by the time t, in order to reach that speed:	**$a=s/t^2$**
Force F is the acceleration a, times the accelerated mass m:	**F=ma**
Energy[d] E is a force F exerted on a mass m over a distance s squared:	**$E=mv^2$**

Masses, however, appear to have a maximum mutual speed c ≈ 300 000km/sec (the speed of light).[e] At that maximum speed more energy added cannot end up in a higher speed v (being at its maximum c). So, it must result in mass m, according to: **$E=mc^2$**.[f]

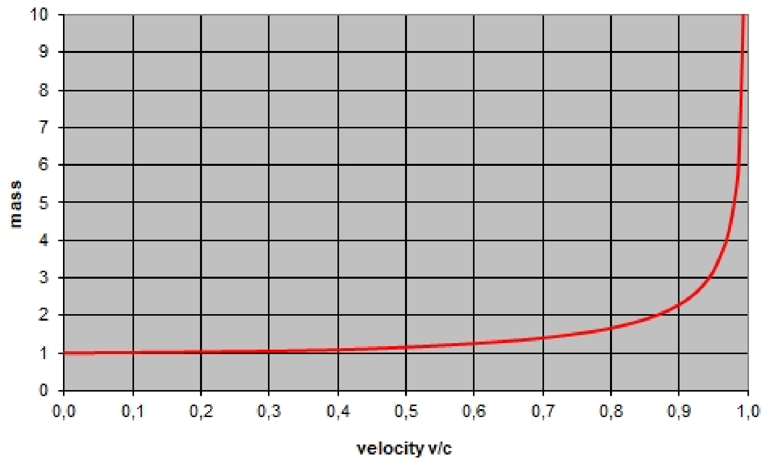


Fig. 164 Lorentz' mass increase through velocity

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a Einstein(1905)Zur Elektrodynamik bewegter Körper(Annalen der Physik)17 p 891-921 http://onlinelibrary.wiley.com/doi/10.1002/andp.19053221004/epdf en Einstein(1905)Ist die Trägheit eines Korpers von seinem Energieinhalt abhangig?(Annalen der Physik)18, p 639–641 http://myweb.rz.uni-augsburg.de/~eckern/adp/history/einstein-papers/1905_18_639-641.pdf

b See for example Young(1964)Fundamentals of Mechanics and Heat(New York)McGraw-Hill

c Newton(1687)Philosophiae naturalis principia Mathematica(London) https://openlibrary.org/books/OL25646536M/Philosophiae_naturalis_principia_mathematica

d Until here Newton(1687), but further applies Einstein(1905)

e The Dutch Beeckman(1634)Journal tenu par Isaac Beeckman de 1604 à 1634 Tome III already came up with a method to calculate c (http://adcs.home.xs4all.nl/beeckman/III/1634.html#lumen), but Rømer (1676) "A Demonstration concerning the Motion of Light". Philosophical Transactions of the Royal Society 12 (136): 893–4. 1677 really calculated c from astronomical observations. On the 15th Conférence Générale des Poids et Mesures (CGPM) in 1975, the speed of light c was finally set at 299 792 458 m/s. The Dutchman Lorentz(1895)Versuch einer Theorie der electrischen und optischen Erscheinungen in bewegten Körpern(Leiden)Brill proved that a moving mass m is larger by a factor λ, so that $m_{moving}=\lambda m_{in\ rest}$, where $\lambda = (1-(v/c)^2)^{-½}$. This 'Lorentz factor' λ and therefore your moving mass, would become infinite if you would approach the speed of light c. Close to c you then have to use an infinite amount of energy to speed up. Thus c is a maximum speed for masses.

f Acceleration beyond light speed is imaginary, because it requires more than infinite energy. As a thought experiment, however, it is a simple shortcut into the complicated mathematics of the special relativity theory of Einstein(1905).

This mass building-up already starts from 0m/sec onwards by any acceleration, but at low v compared to c (v/c) the mass increase is immeasurably small (***Fig. 164***)[a].

MASS INCREASES, BUT TIME[b] AND DISTANCE SHRINK THROUGH MUTUAL VELOCITY

Imagine you move away from me with ⅓c≈100 000km/sec (1km/10µsec[c]).
Your travel is shown as a red line in ***Fig. 165***. We both start at the origin (0, 0).
I don't move (blue vertical axis). I travel in time only, not in space (horizontal axis).
In ***Fig. 166***, however, you (now 'in rest') see me disappearing behind you. At 10µsec, you send me a light signal (yellow arrow)[d], which I mirror 90° back to you. The light reaches you over the same distance (3∗a), but your grid has shrunk into √4.5/√5≈95%.

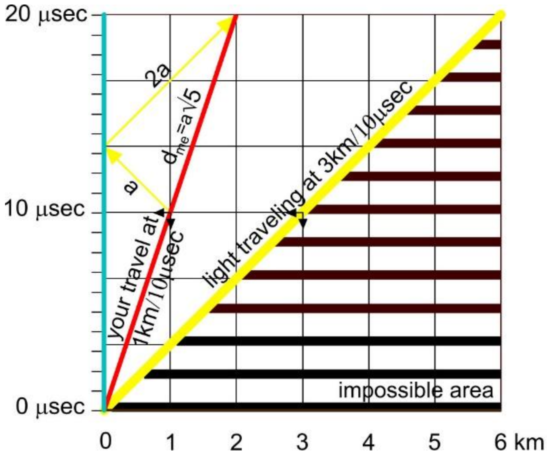

Fig. 165 ***Your travel in my world***

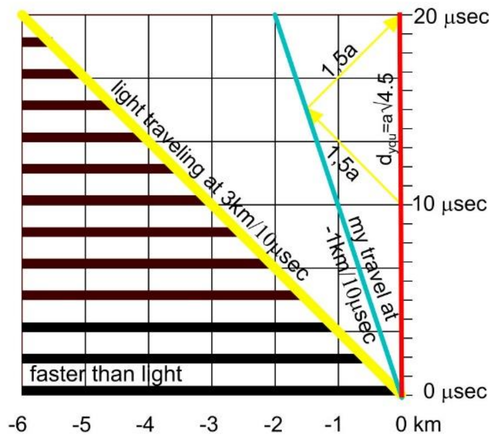

Fig. 166 ***My travel in your world***

Because c is a constant, 1**µ**sec equals 0.3km, so 3⅓**µ**sec=1km.
As a result, the axes in each graph become geometrically equivalent as 'space-time'.[e]
So, I could draw a km∗km grid in both cases.

In ***Fig. 165*** the red route you travel during the time that your yellow signal is on the way (with a rectangular detour reflected through me), is the slanted side d_{me} of a right triangle. According to Pythagoras $d_{me}^2 = a^2+(2a)^2$, so $d_{me}=\sqrt{(a^2+(2a)^2)}=\mathbf{a\sqrt{5}}$.

In ***Fig. 166*** you do not move (the red line is upright), but I take off behind you. Then, your yellow rectangular triangle looks different. In both cases, the light travels the same distance in the same time (a+2a=1.5a+1.5a), but your slanted side d_{you} is $\sqrt{((1{,}5a)^2+(1{,}5a)^2)}=\mathbf{a\sqrt{4.5}}$. So d_{you} (10µsec) is 95% smaller than with me (d_{me})! [f]

a Lorentz(1895)Versuch einer Theorie der electrischen und optischen Erscheinungen in bewegten Körpern(Leiden)Brill https://de.wikisource.org/wiki/Versuch_einer_Theorie_der_electrischen_und_optischen_Erscheinungen_in_bewegten_K%C3%B6rpern

b Nicely demonstrated by http://galileoandeinstein.physics.virginia.edu/more_stuff/Applets/Lightclock/home.html

c A µsec is a second/million.

d The thick yellow diagonals represent the speed of light c (3km/10µsec). Each slope parallel to that yellow line (or back perpendicular to it) equals that speed. It is the same for you and me. Even with a moving light source, c remains the same forwards and backwards, proven by the experiments of Michelson;Morley(1887)On the relative Motion of the Earth and the Luminiferous Ether(American Journal of Science)XXXIV p333-345

e Minkowski(1908)Die Grundgleichungen für die elektromagnetischen Vorgänge in bewegten Körpern(Nachrichten der Gesellschaft der Wissenschaften zu Göttingen)Mathematisch-Physikalische Klasse p53–111

f I chose convenient figures. For all speeds and more generally, a derivation applies with other triangles. You now *pass* me at a shortest distance p. Exacly at that moment I send you a light signal. It travels a distance r at speed c in order to reach you while you have traveled a distance q at speed v. According to Pythagoras, $p^2+q^2=r^2$. Now divide everything by r^2: $p^2/r^2+q^2/r^2=1$ or $p^2/r^2=1- q^2/r^2$. The ratio between p and r $p/r=\sqrt{(1-q^2/r^2)}$. In the time r/c that the light is traveling along r, you traveled the distance q=v(your speed)∗r/c. Now $p/r=\sqrt{(1- v^2r^2/r^2c^2)}=\sqrt{1 v^2/c^2}$, or simply $p/r=\sqrt{(1-(v/c)^2)}$. That is the *shrink* factor 1/γ! In this, γ is the famous Lorenz factor, with which your mass *grows*.

ACCELERATION DRAWS YOUR SPACE-TIME CROOKED COMPARED TO MINE

In ***Fig. 167*** I project your world (red) as warped in my grid (black). Your second and meter are smaller. The *time* is smaller *for those who move in relation to an observer*.

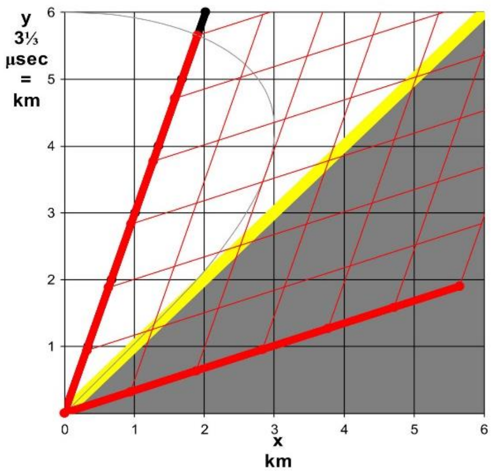

Fig. 167 My projection of your world

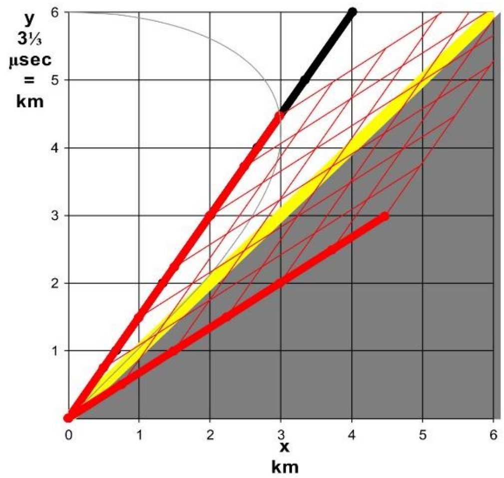

Fig. 168 The same with double speed

In 1905 Einstein had advanced so far with his *Special* Theory of Relativity, thanks to the concept of 'local time' by Lorentz (1895).

How could you understand acceleration now? After ten years Einstein's *General* Theory of Relativity (1916)[a] answered. The accelerations in ***Fig. 169*** show curved lines (more and more kilometers are being made per sec). Time and space are curved.

In ***Fig. 169*** the acceleration forward is positive, retardation is simply a negative acceleration (***Fig. 170***). More masses in a universe then cause waves and swirls in the infinite space-time of accelerations.

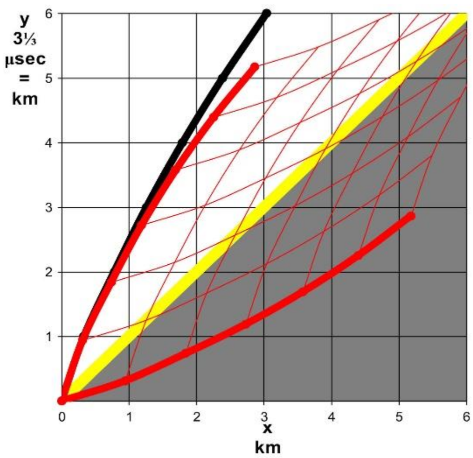

Fig. 169 Acceleration

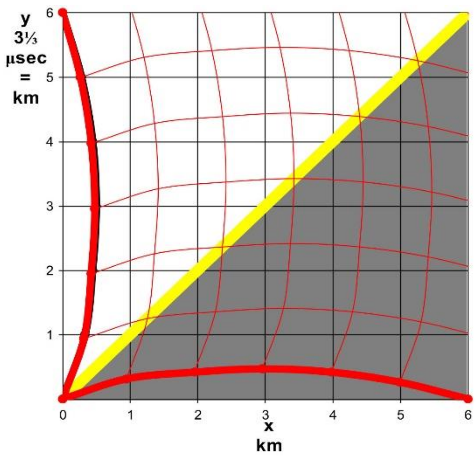

Fig. 170 Retardation

A free floating mass m can be accelerated or deviated only by gravity or by electromagnetic force. Gravity is measurable in the vicinity of a mass only.

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a Einstein(1916)Die Grundlage der allgemeinen Relativitätstheorie(Annalen der Physik)IV 49 p769-822
http://onlinelibrary.wiley.com/doi/10.1002/andp.19163540702/abstract

That curvature is therefore the influence of mass.
Your coordinates curve in the vicinity of a mass, an accelerative force.
In fact, gravity *is* that curvature of space-time!

We have always assumed that light in vacuum follows a straight line. This is not true for the light beam with accelerative forces in the vicinity. For an observer a beam of light has to deflect in the vicinity of a mass even more if space itself is curving.

You should be able to see a galaxy behind the sun twice as earlier as expected before it can appear at the edge of the sun according to calculation. That is exactly what Eddington[a] demonstrated for the first time during the solar eclipse on 29 May 1919.

Lorentz' mass growth γ (***Fig. 164*** p185) makes the gravitational landscape even more complicated, because there are countless masses in the universe moving away from you or coming towards you. If you ever come back, then I have grown old faster than you, but you are not as heavy as you were on the way.

a Eddington(1920)Space time and gravitation An outline of the General Relativity Theory(Cambridge)University Press
http://www.gutenberg.org/files/29782/29782-pdf.pdf?session_id=a60a38a8e2635a9ee437a880211f4b09acb4dd27

§ 33 QUANTUM MECHANICS SUPPOSES UNCERTAINTY

IF YOU KNOW ONE PROPERTY, THEN YOU CANNOT KNOW OTHER PROPERTIES

At the level of molecules, atoms, their parts (electrons, neutrons and protons) and even smaller particles[a], there are other field forces than gravity[b]. They keep such particles together at a much shorter distance. These forces are not immediately measurable, because the smaller size and mass, the less you can determine other properties without disturbing them by your observation (eg with light particles, photons).

If you are already certain about their trace in a medium, then you cannot be sure when what occurred.[c] You can only calculate the *probability* where and when it was. Einstein and many others did not believe that probability was the end of the story: 'God does not play dice' ('determinism', Copenhagen interpretation).

PARTICLES DISPERSE AS WAVES DO

If you send electrons through a narrow slit, they seem to spread behind that slit in wave circles as it is known in a water surface. With two slits, these wave circles also alternately extinguish and strengthen each other ('interference') when they meet (like around two stones that you throw simultaneously in the water).

Conversely, light does not let itself be divided endlessly into even smaller light pulses, so you have to conclude that there are smallest packages ('quanta') of light (light particles, 'photons'). This ambiguity ('quantum waves') only becomes visible with small particles. If each wave field also has a particle character, gravity must also have a force-transmitting particle, although this has not yet been observed. For the time being it is called 'graviton'.

LIGHT SUPPOSES ENERGY WITHOUT MASS

Photons move at c=299 792 458 m/s, so according to Lorentz they should have an infinitely large mass. Then you have to conclude that they have no mass, but that is again in contradiction to the fact that they *do* have an energy $E=\mathbf{m}c^2$, even if m=0. You can generate electrical energy with photocells from sunlight, after all. Moreover, you can measure radiation pressure on a surface of any type of radiation, a kind of 'radiation wind' on which your spacecraft could sail.

GRAVITY IS NOT YET OBSERVED AS A PARTICLE

In the meantime, the physicists have already destroyed many known particles with their particle accelerators. This has resulted in a large number of smaller particles with different properties. They distinguished them into groups, have given them all a name, but most of them live so short that you never meet them outside of those accelerators.

There are various mathematical constructions to find some regularity in the properties of those particles (for example, the 'Standard Model'). In a list with combinations of

a Quarks (from which protons and neutrons are composed), leptomes (like the electron) and bosons (like the photon).
b Electromagnetic forces (transferred by photons), strong nuclear forces (gluons), weak nuclear forces and other (bosons).
c Heisenberg(1927)Über den anschaulichen Inhalt der quantentheoretischen Kinematik und Mechanik(Zeitschrift für Physik) 43 3–4 172–198

such properties, there are particles missing that have not yet been observed.
It is then a challenge to demonstrate a missing combination as an existing particle.

Most particles have an antiparticle, which shoots in the other direction than the particle after some splitting. Their traces are then symmetrical. So, they both have the same properties of mass and lifespan, but their charge is opposite.
If a particle meets its anti-particle, they both disappear leaving energy behind (I then think adding energy you can split 'the nothing' into something and an anti-something).

The majorana particle, however, turns out to be its own anti-particle, without immediately disappearing. The graviton still remains untraceable.

QUANTUM ENTANGLEMENT SUPPOSES MORE DIMENSIONS THAN SPACE AND TIME

There is also a ghostly phenomenon called 'quantum entanglement'.
Quantum particles have measurable properties such as a direction of rotation ('upward spin' or 'downward spin'). That direction can turn around, and usually that twofold state is divided randomly between different particles.

If two identical particles are created by the disintegration of a larger particle, then they keep an opposite spin. That spin gets a value as soon as you measure it.
Now it is ghostly, that if you measure one spinning particle with the one quantum, the other one also changes immediately, no matter how far apart they are.
This has been proven over a distance of 1.3 km by Hanson and Hensen (2015)[a].

According to Einstein, this is impossible, because information from one particle can never be transmitted to the other particle faster than light. If it is a mysterious information transfer, it should go faster than light. Maybe they stay close in a 'fifth dimension' to take up an opposite charge. To reconstruct something like this mathematically, however, you have to suppose more dimensions ('string theory').

THEORIES OF EVERYTHING REMAIN INCOMPLETE

Both relativity theory and quantum theory are good predictors. They are used everywhere. The mathematical simulations work excellently, but to *imagine* quantum behaviour is almost impossible. It remains also insufferable that two so different theories (deterministic and mainly statistical) cannot be united.

Quantum theory cannot get a grip on gravity and determinists cannot determine entanglement or accept statistical uncertainty. Thermodynamics, however, is already since long accepted as a sound branche of physics, based on statistics.

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a Hanson c.s.(2015)Loophole-free Bell inequality violation using electron spins separated by 1.3 kilometres(Nature) 526, 682-686; Wayenburg(2015)Quantummechanica De werkelijkheid is nu bewezen spookachtig(NRC)0828 and a comic strip that gives an exciting account of that evidence: Kriek;Calmthout(2015)Het spook van Delft Quantumfysica(Volkskrant)1024

§ 34 THERMODYNAMICS CONNECTS TWO LEVELS OF SCALE

WORK AND HEAT SUPPOSE ENERGY AT DIFFERENT LEVELS OF SCALE

The tube of a cycle pump gets warm as soon as you start pumping.
You lost some labor (movement in one direction) as heat (molecule movement in all directions). The rest is stored as the 'potential energy' of the compressed air.

That remainder can be reclaimed as work, lifting a weight if you release the pump. As a whole, no energy has been lost (the First Law of Thermodynamics), but you lost the 'energy quality' of directed movement (Second Law of Thermodynamics).

If you close the end of the hose (so that no air can escape) and you push the piston 20*cm* downwards, then you feel an increasing counterforce from 0*cm* into 20*cm*. Assume, it matches at last 10*kg* weight, that is 10*kgforce*=98*newton*=98*N*.

The *energy* you delivered (work W) is force times distance, f∗s *Nm=joule=J*.
The distance, however, increases from 0 to 0.2*m*, and so increases your work W from 98*N**0*m*=0*J* into 98*N**0.2*m*=19.6*J*. At average your *work* W=9.8*J*, is half of 19.6*J*.[a]

INFINITELY SUMMING INFINITELY SMALL SURFACES PRODUCES A FINITE SURFACE

Assume that at each point the ratio f/s is constant: f/s=49/0.1=98/0,2=490. So, f=490∗s.
That is a straight line in ***Fig. 171A***. From that graph you can easily read the growing energy f∗s geometrically as the surface of the right-angled triangle (½ ∗ 0.2∗98= 9.8).

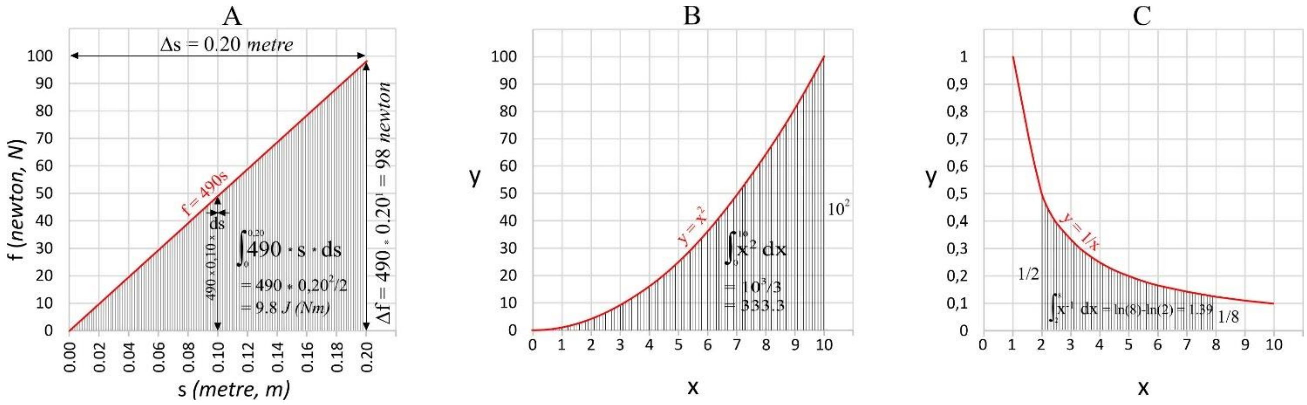


Fig. 171 Calculating areas from the sum of infinitely many infinitely narrow rectangles

You can, however, also calculate that with a 'definite integral'.
Continuing § 26 p135 on calculus, I use this example as a mathematical intermezzo, in order to demonstrate how to calculate it, even if the line would be curved.

You may sum all forces f=490s (growing with s) step by step. Make each step indivisibly small ('ds'). Multiply each f by 'ds' into an indivisible narrow rectangle. Its surface then is f∗ds. Sum all surfaces between s=0 to s=0.2 and write ' $\int_0^{0,2} 490s*ds$ '. Fortunately, there are simple calculation rules for many kinds of integral productsums.

The rule for exponentials reads: 'increase the exponent by 1 and divide by that result'. The 'exponent' of s^1 is the power 1. Increased by 1 is 2, so divide s^2 by 2.

a This is a simplification, assuming an 'ideal gas'.

With that calculation rule $\int_0^{0.2} 490s^1 * ds = 490s^2/2$.
For s choose the largest (0.2). The result is $490*0.2^2/2=9.8$, as we already knew.
You should actually subtract the same with the smallest $s=0$, but $-490*0^2/2$ is zero.

In ***Fig. 171B***, with the same rule '$\int_0^{10} x^2 * dx' = x_{max}^3/3=10^3/3=333.3$.
In ***Fig. 171C*** write $y=1/x$ as $y=x^{-1}$.
With the same rule, the integral would be $x^0/0$, but you cannot divide by zero.
Moreover, there are two boundaries (2 and 8) that are neither zero.

For x in the denominator (/x), another rule applies: $\int_2^8 x^{-1}\,dx=\ln(x_{max})-\ln(x_{min})$.
In this case, that is ln(8)-ln(2)=1.39. (The natural logarithm 'ln' has been explained on p137.) After this mathematical intermezzo let us go back to the cycle pump.

DECREASING VOLUME INCREASES FORCE, PRESSURE AND TEMPERATURE
The directed energy (work) you stored in the cycle pump pressing 20cm, is the sum of all increasing forces times their indivisibly small distances between 0 and 0.2m.
Your work reduced the volume (V_1 into V_2), and it increased the pressure (p_1 into p_2).

'Volume' V is expressed in m^3 and 'pressure' p as force in newtons (*N*) per m^2.
Their product $pV (N/m^2 * m^3=Nm=joule\ J)$ thus represents an energy.
The increase of energy in the pump is $V_2p_2-V_1p_1$.
Your external work is calculated earlier as $\int_0^{0.2} fs\, ds = \int_0^{0.2} 490s\, ds = 490*0.2^2/2=9.8J$.

Temperature T is a measure of the average kinetic energy per molecule.
If there is no longer any molecule moving, then T is '0 *K*'.
That zero *kelvin* = -273,15°*C*. The units of *celcius* and *kelvin* are the same.

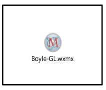
Now take $6.022141*10^{23}$ molecules of air[a] (a '*mole*'. see p216), at temperature T.
The number of *moles* n=1. Their heat energy pV appears to be nRT joule, where R=8,314 462 618*J/(K*mole)* ('gas constant') valid for any gas. So, pV=nRT(*J, joule*).
Written as pV/T=nR (a constant) it is known as the 'Law of Boyle-Gay-Lussac'.[b]

If your cycle pump has an internal diameter of 3.6 *cm* ('bore'), then the piston has a surface of 10cm^2 ($\pi*1.8^2$). The atmosphere presses already with ca.10*kgf* on 10cm^2.
That is 1kgf/cm^2, or nearly $10N/cm^2=100\ 000N/m^2(Pa)=1bar$[c], nearly our normal air pressure.
The 54 *cm* long cylinder contains 540 cm^3 of air (at 25°*C*: 0.7 *gram* or 0.024046 *mole*).

Now pump down 20cm (your 'stroke') very fast. The pressure was 1 bar and you added the same, pressing 1$kgf/1cm^2$. So, you have doubled the air pressure in the tube.
The number of molecules (*moles*) does not change, but the volume becomes $540-200=340cm^3$ (540/340 is called the 'compression ratio').

a Here I am pretending that air consists of equal molecules.
b Boyle proved in 1660 that pV is constant at the same temperature, Gay-Lussac did that in 1802 for V/T at equal pressure and Clapeyron in 1834 for pV/T=nR at n=1*mole*.
c Our air pressure is approximately 100 000N/m^2, 100 000 *pascal*, '*Pa* ', 1000 *hectopascal* '*hPa*' or 1'*bar* '.

You have *increased* pressure from the atmosphere p_1=100 000N/m^2 into p_2=200 000N/m^2.
You have *decreased* the original volume from V_1=0.00054m^3 into V_2=0.00034m^3.
The increase of energy in the pump is V_2p_2-V_1p_1=14J, but 'stepwise' (∫) 7J.



What about the temperature? Let us for the time being forget stepwise integration (∫).
According to Boyle-Gay-Lussac pV/T is constant, so $p_1V_1/T_1=p_2V_2/T_2$.
The initial temperature T_1 was 298.15K = 25°C. Then the new temperature must be
$T_2=T_1p_2V_2/p_1V_1$=298.15∗200000∗0.00034/(100000∗0.00054)= 375K. That is 375-273,15=102°C.[a]
Your cycle pump is a heater!

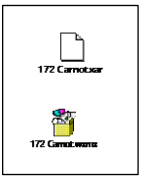
If you release the cycle pump, the piston will shoot up again, but not completely.
The cylinder lost some heat in the mean time.
Lacking that heat, the temperature inside the tube becomes lower than T_1.
Pull the piston higher. T decreases more. Your cycle pump has become a refrigerator!

Let the corresponding volume of air escape, until the piston has dropped 20cm.
Then close the hose again. Now put the cycle pump in boiling water.

The pressure will rise, so that the piston will rise. There is less air to expand (you have let it escape), so it will not reach 20cm, but it can lift a weight over some distance.
The supplied heat ΔQ is then partly converted into work W.
Your cycle pump has become a motor!

THE CARNOT MOTOR EXTRACTS WORK FROM A DIFFERENCE OF TEMPERATURE

Carnot(1824)[b] invented a method in order to extract work (directed movement) from heat (molecules moving in all directions). Imagine four cycle pumps on a wheel in a cold environment with a hot flame below (***Fig. 172***).



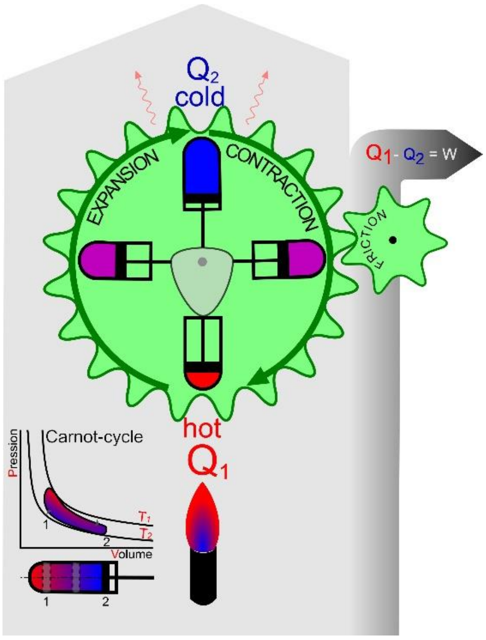


Fig. 172 A Carnot-engine

Q_1 heat enters the cylinder, the volume V expands.
A smaller part Q_2 escapes by cooling, V contracts.

The difference ΔQ is the amount of work delivered:
W= Q_1-Q_2=ΔQ (- a neglected part, lost by friction).

The temperature T_{hot} cooles into T_{cold} : –ΔT, and the reverse heats +ΔT, stepwise with Q (ever decreasing, but each cycle supplemented), loosing work W=ΔQ.
Work W or heat is 'pV' in pV/T=nR=constant.

W is also the integral sum of pressures p (=nRT/V) times each momentary change of volume dV:

$$W = \int_{Vmin}^{Vmax} p\, dV \;=\; \int_{\mathrm{Vmin}}^{\mathrm{Vmax}} \mathrm{nRT/V\, dV} \;=\; nRT \cdot \int_{\mathrm{Vmin}}^{\mathrm{Vmax}} \mathrm{1/V\, dV}.$$

R, n, and T (=T+ΔT-ΔT in the cycle as a whole) are constants. So, they can be put outside the integration.

a If you take a more realistic normal air pressure of 1011,3hPa, then it is 94°C.
b Carnot(1824)Réflexions sur la puissance motrice du feu et sur les machines propres à développer cette puissance(Paris)Bachelier Libraire, http://www.numdam.org/article/ASENS_1872_2_1__393_0.pdf

One '*mole*' of gas contains $m = 6{,}022 * 10^{23}$ molecules (Avogadro's number N_A).
Assume n=1*mole*, R=8.31 (gas constant), T is also constant, and V_{max} is $2V_{min}$, then
$\Delta Q = W = nRT \cdot \int_{Vmin}^{Vmax} 1/V\, dV = 1 * 8.31 * T * \int_1^2 1/V\, dV = 8.31 * T * \ln(2/1)$ [a] $= 8.31 * T * 0.693 = 5.76T$.
Divide it by T, then $\Delta Q/T = 5.76$ is called entropy.

ENTROPY SUPPOSES A PROBABILITY OF DISTRIBUTION

Clausius(1854)[b] studied Carnot. He interpreted entropy as a probability of distribution. Molecules hurrying in random directions, always concentrate and disperse locally.

Imagine a cylinder with a gas filling its largest volume V.
The chance that the gas incidentally concentrates in one half V_1 leaving the other half V_0 empty, may be extremely small, *but not impossible*.

You may *calculate* that extraordinary tiny *probability* as an imaginary *possibility*.
With one molecule, that probability is yet ½ (50%).
With two molecules that probability is ¼ ($1/2^2$), with three molecules $1/2^3$ (***Fig. 173***).

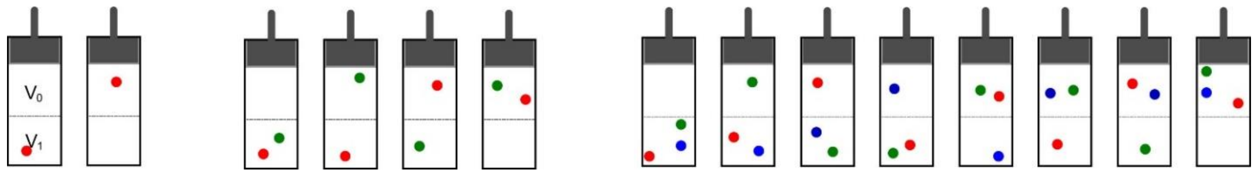


Fig. 173 All possible distributions of 1, 2 or 3 molecules over two equal halves of a cylinder

With m molecules that probability then is $1/2^m$. The chance that all molecules of one *mole* ($m = 6{,}022 * 10^{23}$) happen to be in V_1 of ***Fig. 173***. is one to 2^m ($1/2^m \approx 1/2^{602\,200\,000\,000\,000\,000\,000\,000}$)

If you do not choose a compression up to ½V, but up to ⅓V or even 1/22V (as in some diesel engines), then that probability is even smaller (not $1/2^m$, but $1/3^m$, $1/22^m$ etc). With such unimaginable small chances, it is better to take the *exponent* at 10, the 'logarithm' log(m), or the *exponent* at 'e', the 'natural logarithm' ln(m), see p137.

Entropy S based on probabilities compares two chances: $S = R/m * \ln(\text{chance}_{\text{all in}V0+V1}/\text{chance}_{\text{all in }V1})$ $= R/m * \ln(2^m/1^m) = mR/m * \ln(2/1) = R * \ln(2) = 8.31 * 0.693 =$ 5.76 (in fact ΔS, but the second chance is practically zero). So, the *chance theoretic* $S = R/m * \ln(\text{chance}_1/\text{chance}_0)$, equals the *gas theoretic* $S = \Delta Q/T$.

A crystal, ice, or a system of motionless molecules near the absolute zero point of temperature (T= 0*K*) have a lower entropy S (higher order) than liquid or gas with higher temperatures, but their absolute values are difficult to determine.
Their *differences* Δ, however, can be calculated based on measurements.

The real zero point of disorder (the highest degree of 'order') is never reached, because a temperature T=0 *K* is unattainable, although experiments are close to it nowadays. Something similar applies to the highest degree of disorder.

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a The use of 'ln' is explained on p137.
b Clausius(1854)Ueber eine veränderte Form des zweiten Hauptsatzes der mechanischen Wärmetheorie in(Annalen der Physik und Chemie)93 12 p481–506 https://ia800908.us.archive.org/31/items/abhandlungenber00claugoog/abhandlungenber00claugoog.pdf

If you take the piston out of a cylinder, then the system boundary shifts, and V_0 suddenly encompasses the entire atmosphere, so that V_1 is an even smaller part of it. A total dispersion of matter in the universe would represent the highest entropy. Spreading seems inevitable, even though we see local and temporary concentrations.

Two mutually approaching particles may pass each other or collide. In both cases the convergent (concentrating) movement →← changes necessarily into a divergent ←→ (dispersing) movement. This mechanical process increases entropy. It is not reversible without an enclosure of concentrated matter. The arrow of time cannot be reversed.

If you do not want to wait until the gas accidentally concentrates in one half of the cylinder (with a probability of 1 in $2^{602\ 200\ 000\ 000\ 000\ 000\ 000\ 000}$ cases), then you should deliver an amount of pumping work W.

WORK OUT OF HEAT SUPPOSES LOSS OF ENERGY

A steam engine brings water to a boil in a closed boiler.
The saturated steam can reach a temperature of 190^oC and a pressure of $12bar$.
That pressure moves a piston in a cylinder on one side (or alternately on both sides).

If after that first stroke, the expanded and cooled steam is discharged by the receding piston, then the process can be repeated. Various constructions have been developed for the timely opening and closing of fuel supply and discharge, for example the 'camshaft' used in cars, which opens and closes at least two 'valves' per cylinder.

Since the invention of the 'ottomotor'[a], the fuel is hardly used anymore to generate steam pressure, but the fuel itself has been ignited, exploding in the cylinder.
A gas mixture (for example 1 part petrol on 15 parts air) explodes, provides the necessary pressure, and the burnt gas is emitted via the exhaust.

Normally two expansion and two compression strokes are required: an *expansion* stroke to collect the fuel, a *compression* stroke (10-18 bar 300-400 °C) to ignite it with an electric spark (generated by a 'spark plug'), so that the subsequent *expansion* stroke provides work and finally a *compression* stroke brings the burnt fuel outwards.

Since 1892, gas mixtures have been used that spontaneously ignite in a 'diesel engine' at 256^{o}C without a spark plug.[b]
In order not to ignite too early ('pinging' or 'knocking'), the fuel should be injected fast under high pressure during compression (25-50bar).

Then there is an even faster explosion than with the ottomotor, so that more cycles (revolutions) can be made per second.
For the wider application of the diesel engine after 1920, it was therefore waiting for a more effective execution of the at the time underperforming fast injection pump[c].

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a The first combustion engine has been invented by Isaac de Rivaz in 1804, improved by Jean Joseph Etienne Lenoir in 1860 and at last successfully improved by Nicolaus Otto in 1876 ('ottomotor').

b The first Diesel engine has been invented by Diesel(1886)Theorie und Konstruktion eines rationellen Wärmemotors zum Ersatz der Dampfmaschine und der heute bekannten Verbrennungsmotoren(Düsseldorf 1991)VDI Verlag. He constructed the first operating Diesel engine in 1892.

c The long road to an commercially valid fuel injection device is described in http://www.disa.it/pdf/01HystoryOfDieselFuelInj.pdf. Bosch succeeded at last in 1927.

A Stirling engine has no inlet or outlet.
It heats the same gas and cools it down on the other side of the piston again.

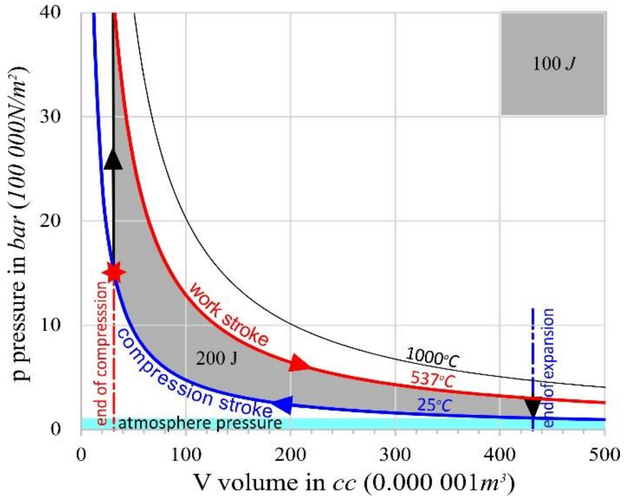


Fig. 174 pV graph (Boyle-Gay-Lussac) in a passenger car

Fig. 174 (the cycle of a passenger car), shows a pV-graph for two temperatures T from the formula pV/T=nRT of Boyle-Gay-Lussac.

You can see how much work such a cycle can yield:
p∗V (energy) equals the grey surface.[a]

So, one cycle in one cylinder yields 200J of work, and 6000 rotations per *minute* (*rpm*) or 100 per *second*, yields 100∗200*J* = 20 000*J/sec*.

With 3 cylinders that is a power (energy per second) of 60 000*J/sec*. Because *J/sec* is called '*watt*' or '*W*', that is 60*kW*. In the past that was called 82*hp* (horse power).

The surface *under* the 'compression stroke' represents the work needed to compress the air at that stroke. Up to 1bar, the atmosphere has a share in it.
Without the help of that pressure, compressing would cost more energy.

One stroke of 0.0004m^3 takes about 6% petrol mixed with the necessary air.
It has a calorific value (heat production) of $Q_1 = 872J$, but only 200*J* is used for work.
The return (efficiency) $\eta = W/\Delta Q$ then is 200/872=23%.
The remainder, $Q_2 = 672J$, is lost as heat (see also ***Fig. 172*** p193).

The left vertical arrow in ***Fig. 174*** represents the moment after ignition where suddenly 872J of heat (Q_1) is released in the cylinder.
The pressure immediately rises. In reality, however, the arrow will not be vertical, but during the ignition it will take a moment to the left (less volume) and then take a smooth bend to the right towards the work stroke (increasing volume).

If the volume really did not change, the temperature would rise to 537 °C.
It is unlikely that this will happen, because as the pressure rises, the heat loss and the volume increase already begins. It does not take long before the volume increases and the pressure quickly decreases (see the small graph in ***Fig. 172***).

Fig. 174 shows that a passenger car needs a temperature difference ΔT of 527-25≈ 500°C to yield enough work and power. A racing car may require more than 1000°C. The bigger that difference, the more lost heat you could still re-use (theoretically

a $\int nRT_{max}/V\,\delta V - \int nRT_{min}/V\,\delta V$, both determined between V_{min} en V_{max}, that is $nRT_{max}(\ln(V_{max})-\ln(V_{min})) - nRT_{min}(\ln(V_{max})-\ln(V_{min})) = 200J$.
Where n=0,02005mole; R=8,314J/Kmole; T_{max}=525,965+273,15=799,115K; T_{min}=25+273,15=198,15K; $V_{max}=0{,}034m^3$; $V_{min}=0{,}0031m^3$.

yielding a higher total energy use, 'exergy'). For example, you could still run a small steam engine or Stirling engine using the very hot exhaust fumes of a racing car.

The same amount of heat Q at high temperature has apparently more 'energy quality', less entropy than at a lower temperature.

If the entropy ΔQ/T increases, then the ability to produce work is reduced.
This process goes by itself and is 'irreversible', if you do not add external work W in order to get a higher temperature T by compression.

IT IS EASIER TO MEASURE A DIFFERENCE, THAN AN ABSOLUTE VALUE
Any heat or work entering or exiting a system, changes its internal energy U.
That U itself is difficult to measure or to calculate.

If you would have to include the mass according to $E=mc^2$ (p185) as potential energy, the potential decomposition energy of all molecules (bindings represent energy, see ***Fig. 183*** p218), the kinetic energy of their spinning, and other contributions, then you may better measure or calculate the difference ('ΔU') between two states only.

You can determine ΔU from the incoming and outgoing energies ΔQ+ΔW.
A difference Δ then is a difference between two 'states' of a system or between two systems in a different state. Do not forget Δ is bridged in small steps d. Their sum, integrating Δ into ∫d can still produce higher or lower values (***Fig. 82*** p135).

CHANGING THE TEMPERATURE OF 1KG REQUIRES DIFFERENT AMOUNTS OF HEAT
If you heat 1*kg* of air (34.5*mol* or 1.2m^3) at 20^o*C* (293.15*K*) into 21^o*C*, without change of *pressure* ('isobar') you have added 1003*J* of heat Q. That 1003*J* per ^{o}*C* or *K* and *kg* is the 'specific heat at equal pressure' ('c_p') of air. That air has only got a larger volume.
With c_p you counted the work, which the air needed to lift the atmosphere, in other words: to overcome the atmospheric pressure of the environment.

If you keep that *volume* the same ('isochore') in a closed vessel, then you have enough with 715*J*. That 715*J*/*K*∗*kg* is called 'specific heat at equal *volume*' ('c_v') of air.

Every different gas, or more generally any kind of material, has another specific heat.
Because liquid or solid hardly expands, there is no difference between c_p and c_v.
Water heating costs for example 4187*J* per *degree* and per *kilogram*, dry brick only 880*J*/(*K*∗*kg*). A brick of 1.75*kg* (5∗10∗15*cm*) heating up one degree costs 1470*J*.
It is the 'heat capacity' of that brick as an object with a given weight.

You should know that when you warm up your home, counting all bricks, furniture and other materials.

§ 35 INFORMATION SUPPOSES FORMATION

INFORMATION SUPPOSES PHYSICAL ACTION

Information can be stored and it can control physical processes.
A footstep is very literally in-formation, an in-pression of physical differences that can be labelled with signs or combinations of signs.

A bivalent (on or off, 1 or 0) sign ('bit') satisfies to make infinite *different* combinations as labels for colors in a drawing ('legend'), characters ('alphabet'), locations ('topography') and so on.

Two bits can be combined in 4 (=2^2) different ways (00, 01, 10 and 11), three in 8 (= 2^3) ways (000, 001, 010, 011, 100, 101, 110 and 111), and n in 2^n ways. The amount of information 'I' counts only the exponent n in 2^n ('the binary logarithm', 'lb' instead of log or ln)[a]. Then I=lb(2)=1bit, lb(4)=2bits, lb(32)=5bits and so on.

In order to be able to distinguish the numbers 0-9, requires lb(10)=3.321928 bits, but a digital computer only processes whole bits and it thus requires 4 bits to do so.
An alphabet with 32 characters requires 5 bits to distinguish each character, because 32=2^5 (***Fig. 175***).

In order to include lowercase characters you need at least 6 bits giving space for 64 different signs. In 1963 The American Standard Code for Information Interchange (ASCII)[b] used 7 bits, later 8 bits, in order to include even more signs (256) such as computer control codes. After 1992 The Unicode Transformation Format (UTF-8) also used 8 bits. The second row of ***Fig. 175*** shows these additions: 010 includes capitals, 011 lowercase, 001 numbers and 000 controls.

0000	0000	0001	0001	0010	0010	0011	0011	0100	0100	0101	0101	0110	0110	0111	0111	1000	1000	1001	1001	1010	1010	1011	1011	1100	1100	1101	1101	1110	1110	1111	1111
010	010	010	010	010	010	010	010	010	010	010	010	010	010	010	010	010	010	010	010	010	010	010	010	010	010	010	010	010	010	010	010
@	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	[	\	]	^	_

Fig. 175 Binary codes for 26 capitals and 6 other signs[c]

A set of 8 bits with 2^8=256 combination options available, is called a 'byte'.
A computer then 'knows' without a stop sign that a new character starts after 8 bits.
The information 'I' per character is then I=lb256=8 bits or 1byte (B).

Human reading takes at average 240 words per minute. With an average word length of 10 characters that is 2400/60=40 characters per second (40 'baud').
If a character is 8 bits, you can read at a speed of 320 bits/second ('bit rate').

a You do not have to worry about using logarithms with base 2 (l bit) instead of 'e' (ln) or 10 (log). They can easily be converted with a constant: lb(x)=1.442 695∗ln(x)=3.321 928∗log(x).
b https://en.wikipedia.org/wiki/ASCII
c https://www.rapidtables.com/code/text/ascii-table.html

In order to digitize *spoken* text, you need 7 bits at least 6000 times per second.
You have to distribute the sound wave ('amplitude') in at least 2^7=128 classes and give each a binary code. A call then takes 42 000bits/second.

A television image with 500 000 points ('pixels') in 16 colors, or (lb16=) 4 bits/pixel, and that 25 times per second, yields 500 000*4*25=50 000 000bits/sec or 50megabits/sec.
Nowadays it is already 256^3 RGB colors (3bytes/pixel), with more than 8 million pixels, 50 times per second (1200 megabytes/sec), but you can 'compress' that.

REPETITION REDUCES INFORMATION VALUE

The information of moving images contains much repetition without new information ('redundancy'). It can be 'compressed' by passing on only the *differences* of each subsequent image keeping much of the previous picture the same (applied in the 'MPEG' compression). Something similar applies to sound and text. A text such as OOOOOOOOOO[a] takes 80 bits (10 bytes), but it has little or no information value.

A small difference NOOOOOOOOO suddenly has much more information value.
The repetition of O's can be understood as an emphasis like NO NO NO…, but for *numbers*, every next 0 also has a different meaning by its *position*.
Then the information '1000' is even more 'informative'.

So, the 'meaning' may be different for different users. How could you then quantify an 'information value' without having to include the meaning ('semantics') itself?

In ***Fig. 173*** p194 all possible distributions of 1, 2 or 3 molecules are represented on two equal halves of a cylinder. You can call those halves 0 and 1 and the number of molecules n to be located can be listed as the exponent in 2^n.

The position of one molecule (n=1) in volume V_0 or V_1 can then be reported with 0 or 1, the position of two molecules (n = 2) with 00, 01, 10 or 11, the position of 3 molecules in 1 of the 2 with 000, 001, 010, 011, 100, 101, 110 or 111, and so on.

The more molecules (the larger n), the smaller is the chance to find them all-in V_1 one half of V (ordered, low entropy). On p194 entropy has been defined as $S=k*\ln(\mathit{chance}_{V \text{ or } V_1})$, a measure for disorder, the opposite of 'value' or 'quality'.

a A text to be analyzed is written here in capital characters, but the analysis does not distinguish between small characters.

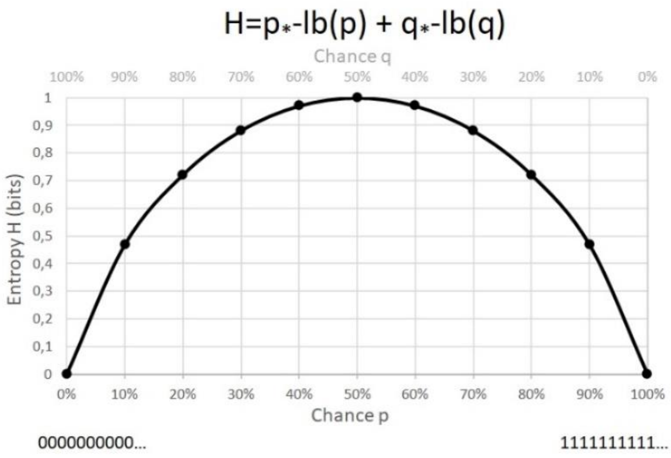


Fig. 176 Shannon-function

Shannon[a] proposed a concept of 'information entropy' (H) to quantify an information *value* without having to include the *meaning* of the message.
It was based on the *chance* p that '1' will be the next sign in a binary code (otherwise '0').

If that chance p is each time100%, then the code will be 1111111111….
If p=0%, then you get 0000000000….
Both cases are easy to compress.

You are sure about what follows, but the *value* of the transferred information is zero.

If there is, however, p=50% chance to get a '1', then there is also 100%-p=50% (write 1-p=0.5) chance on '0'. So you are completely uncertain about the outcome.

'Uncertainty' means that the outcome will have 100% information *value* for you ('self-information'[b], let me call it 'SI'). But what about SI inbetween these extremes?
The amount of information I=lb(2) is one bit but its SI is less, if you already can guess what it will be.

You may reduce I by the chance p: $p*I$ ($p*lb(2)$bits), but then if p=1 (100% certainty) it would also be 1bit ($p*lb(2)=1*1$), while it has not any SI, and if p=0.5 (50% certainty) the SI would also be 0.5 bit, while it must be 100%.

This should be the point that Shannon remembered entropy S=k∗ln(*chance*) as an energy-value. It does, however, not concern gas, so forget k or use k=1.443 to change the kind of logarithm lb(x)=1.443∗ln(x).

If you take SI=lb(p) instead of I (lb(2)), then p∗lb(p) is the chance you may receive *relevant* information (SI). Since lb(chance) is a logarithm of something between 1 and 0 (100% and 0%), it produces a negative number. In order to make it a positive 'value' Shannon used lb(1/p)= –lb(p) to arrive at his final formula for information-entropy (***Fig. 176***) where q is the complementary chance of p (q=1-p).

The information entropy H (uncertainty, relevance) must include that complementary chance q. That is simply adding q∗–lb(q), and q is nothing else than 1-p.
So, the information entropy H is a function of only p: H(p).

According to this function the texts '000 ...' and '111 ...' do have an information entropy H=0, and a random text such as '110100111000' may have offered total uncertainty and thus the highest relevance H=1.

a Shannon(1948)A Mathematical Theory of Communication(Bell Systems Technical Journal)27 379-423, 623-656 p21
b https://en.wikipedia.org/wiki/Self-information

The chance to get '1' is equal to the chance to get '0'. Instead of '1' and '0', you may also choose 'E' and 'any other character' ('not E'). You can even split 'not E' into 'M' and 'not E or M', adding terms with p_E, p_M and $p_{\text{not E or M}}$.

An unweighted probability p that one of the characters from our alphabet appears at any location in a text would be 1/26 (3,85%), taking I=lb(26)=4.7 bits.
Any character, however, has its own probability to appear in a text.

Fig. 119 shows that not every character is equally common. For example, the character E in the English language has a probability p_E=12% to appear in a text and the character M a probability p_M=2.6%. So you can expect 'E' rather than 'M'.

The character E then has SI_E= -lb(p_E)=3.06bits self-information, and M has SI_M= -lb(p_M)= 5.27bits. The chance that you will actually *receive* this self-information is again p_E or p_M, producing p_E*-lb(p_E), p_M*-lb(p_M) and $p_{\text{not E or M}}$*-lb($p_{\text{not E or M}}$). Add all, and you have Shannons entropy of the signal. Remark that the *sequence* (ME or EM) does not yet play a role.

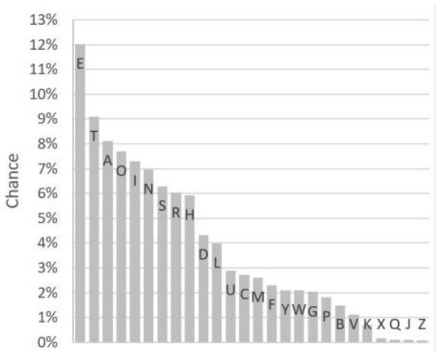


Fig. 177 Characterfrequency[a]

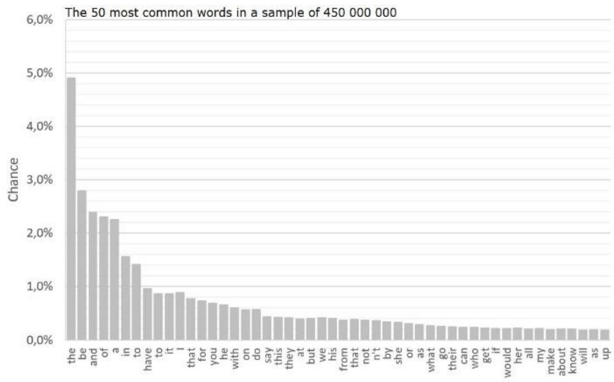


Fig. 178 Wordfrequency

If our alphabet consisted of the characters M and E only, and the 50% probability of M and E in a text would be the same, then the entropy H_E is 1bit, the Shannon maximum. The entropy H_M also, by the way. Then the probability of ME (p_{ME}) would be 50% of 50%, that is 25% or 1 in 4, because EM, MM and EE are equally possible.

However, the four combinations are an 'alphabet' with 4 characters. So, you can no longer just use the binary Shannon function. With 26 characters, the unweighted chance of these combinations is 1/26*1/26=3.8%*3.8%=0.15%. That is much less predictable.

Based on the character frequency in English (***Fig. 177***), however, the probability of ME is 3%*12%=0.4%.
Fig. 178 is based on a word list of 60 000 words in a sample of more than 450 million words. In an alphabet with 60 000 'characters' the probability of ME would be 1/60 000=0.0017%, but weighted to the word frequency in English it is 0.16%.

In order to supplement the expected characters for a computer when you have typed the first characters, the word frequency per language offers the highest chance of these

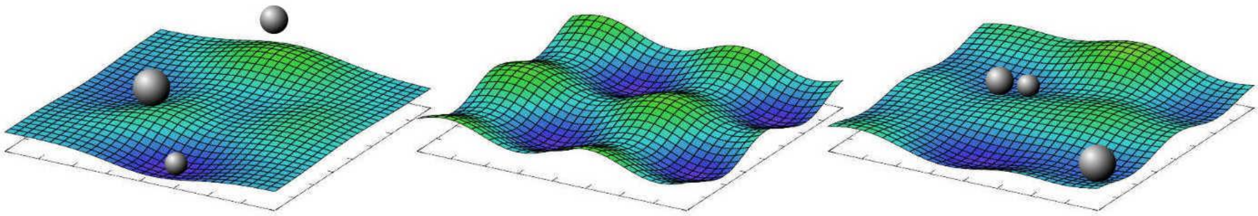
a http://pi.math.cornell.edu/~mec/2003-2004/cryptography/subs/frequencies.html

methods. However, more methods have been devised.
After a consonant often comes a vowel, in a sentence usually a verb must be present, preceded and followed by a noun, and so on.

MEANING SUPPOSES REPEATED IMPACT

In all this the *meaning* (studied as 'semantics') has not been taken into consideration. Haken[a] assumes that the recipient, on the basis of previous information, attaches different importance or weight and thus significance to incoming messages.
That weight can change again after following messages.

He imagines that as an undulating landscape in which information ends up as rain, or rather as heavy bullets. That landscape has flexible mountains and valleys (***Fig. 179***). Of course, these bullets roll straight to the nearest valley, which has already been dented by bullets. That valley is then an 'attractor' for incoming information.



Landschap $N(q,\alpha)$ + Fluctuation $F(t)$ = $N(q,\alpha) + F(t) = dq/dt$

Fig. 179 Attractors in the recipient's landscape, shaken by fluctuations

The whole landscape 'N', however, also vibrates under the influence of external fluctuations 'F', so that bullets can roll to another, deeper or sometimes shallower valley, whereby that in turn becomes deeper, and gains more weight (***Fig. 179***).
The elevation 'q' of each point in the landscape thus changes with time t so that you can write q(t) and also F as F(t).

The whole landscape N, by the way, changes with q, in short: N(q). Each height q changes per second: q/t. That change is recorded as height per time. Every infinitely small change of q (dq) is accompanied by an infinitely small change in time t (dt). So you write dq/dt. There are formulas to give a 'differential quotient' a fair value.

In order to calculate the change of the landscape N(q) apart from its external fluctuations F(t), you limit N(q) with all properties α ('parameters') that would have that landscape N without those fluctuations F. You then note $N(q,\alpha)$.
Each landscape point $N(q(t),\alpha)+F(t)$ is now equal to the change dq/dt (***Fig. 179***).

As soon as you wake up, you will be flooded with information.
It rains bullets with different weight and if they are heavy enough, they end up in your landscape. Your senses are already a filter 'M' that determines their weight and stops light bullets, so that your landscape is hit by impulses with different weight.

a Haken(2006)Information and Self-Organization(Berlin)Springer p19. In addition to precursor in this quantitative semantics, Hermann Haken is mainly a laser expert and a pioneer in physical 'synergetics', the complexity theory that is discussed in the next section.

With every message from outside your landscape changes shape, but you already have your own priorities (attractors), and they do not change easily. However, you are a living organism with mood swings and other fluctuations, so that these messages can conform to other priorities. Haken[a] quantifies that as follows (***Fig. 180***).

179
Haken(2006)Informat

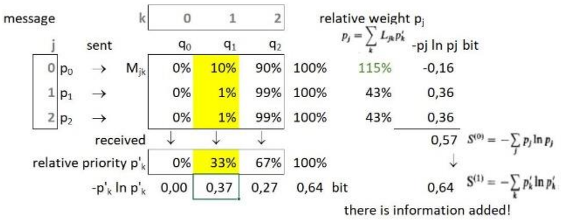
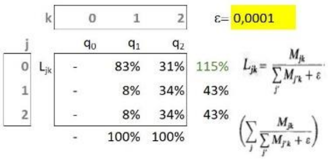


Fig. 180 Weight of messages and priorities of the recipient



Auxiliary matrix L_{jk} (relative weight) at Fig. 180

To keep it simple: take 3 mail messages p_0, p_1, p_2. They do not arrive at first, because you are still asleep, or your computer is switched off (q_0). Then you read them quickly with decreasing interest, but those impulses together have no more priority for you than to start drinking coffee (q_1). Then you read them again (q_2). They now have more weight and together they now have enough *priority* for you to send messages yourself.

By Haken this is summarized in a list (a matrix M_{jk}). The columns k (M_k) contain the relative weights, in percent (100% per row j), each having message p in the row j (M_j). So matrix M is the weight filter so that you receive the different messages p_j, but you do not have given *priority* p'_k to them per column.

They will only receive this priority if they land as bullets with different weights and then roll to a valley (attractor). 'The coin falls' so to speak. These priorities p'_k stand in a separate list with one row (a 'vector') under the matrix M, also in percentages with a total of 100%. It is the *chance* of the information that you could forward.

From that probability p'_k (with $-p'_k * \ln p'_k$) you can easily calculate the information content that you have added with those priorities: 0.64bit. If you compare that with the information you have received, then you have added information with your priorities. Haken then says that you have created 'meaning'.

In order to calculate the amount of information *received*, you must 'normalize' the weights per column to 100% and add them per row.
That happens in the help matrix L_{jk}. You run the risk that the denominator becomes 0. This is prevented by adding a very small number ε to the denominator.

You can fill in all that is yellow as you wish, the rest will follow automatically according to the attached Hakens formulas. Often you also send less information, but you combine messages and give them different weights.

a Haken(2006)Information and Self-Organization(Berlin)Springer p21

This model starts to look like a neuron that receives information of different weight with dentrites and transmits it to other neurons via an axon with a different weight (see also § 28 p150 and onwards).

COMPLEXITY SUPPOSES SURVIVAL AT THE 'FITTEST' SCALE AND INFORMATION
Open systems are usually not in equilibrium, but with steady or fluctuating external supply and dissipation of mass, energy or information, they can suddenly display an order of that balance in their dynamics (a 'phase transition' similar to freezing).

That surprised physicists. Such an ordered situation can also suddenly be described with fewer bits and then resembles reduced entropy.

You would expect an open system to fall prey to increasing entropy if you do not close it off from the disordered outside world. But, for example, a chaotic set of light waves (emitted by atoms in all directions, each time another electron is thrown out of its orbit), caught between mirrors, may suddenly create a narrow beam of highly focused coherent light in the same phase and with the same frequency.
This high energy beam escapes through a hole in the mirror (a 'laser').

Another frequently cited example is the appearance of pure hexagonal Bénard cells in a slowly and evenly heated fluid (***Fig. 152*** p159)[a], or the swivels in chaotic gases (cyclones) and liquids (***Fig. 154*** p160). Such order is easily associated with an 'invisible hand' in economics[b] or in suddenly directed social movements ('hypes' or 'waves' in a stadium), but both are explainable through exact repetition simulated by mathematical iteration (§ 28 p151, see also ***Fig. 9*** p27).

If suddenly a very large number of particles become 'enslaved' and show 'self-organization', then the phenomenon is called 'emergent'.
An emergent complex open system may
(1) differ from the external rest ('identity'),
(2) have some internal equality ('order'),
(3) remain the same despite changes in that environment ('stability'),
(4) adapt to it ('adaptation'), or even
(5) adapt that environment to itself ('accommodation'), known from biological growth and reproduction. Finally,
(6) such a system may be divided into mutually connected subsystems with different functions ('specialization').

As far as I am concerned, these are characteristics of *increasing* complexity.
Freezing, swirls, Bénard cells and lasers do not go beyond self-*ordering* by iteration (2) and some stability (3). I would speak only of '*organization*' at (6).

a Bénard(1900)Les tourbillons cellulaires dans une nappe liquide(Rev Gen Sci pures et appl)11 1261-1271 & 1309-1328
b Supposed in Smith(1776)An inquiry into the nature and the wealth of nations(London)

There is no unambiguous definition of 'complexity' and 'self-organization', but it is apparently agreed that complexity ought to lie Between Order And total Randomness ('BOAR'), difficult to describe, to develop, to design, and to predict ('DEEP').[a]
Without a better definition than these two, it is an embarrassing concept for something the author apparently does not understand ("It is sooo complex").[b]

Haken[c] claims to be able to capture synergetic 'complexity' in complex mathematics. If it distinguises order and disorder, then I would define it as 'different differences that change less than their environment at different levels of scale'.
That also appeals to designers: make a difference. Making equal is not the art.

For example, a city as a complex system[d], differs from its surroundings for a long time. Within the city (at a lower level of scale) the neighborhoods, industrial areas and parks differ from their different content, form, structure, function or intention.

Within these, the facilities or buildings differ again, to name but a few of the many scale levels of the city and its diversity.
This 'complexity' (6) does go far beyond Bénard cells and lasers (2).

All these *separate* differences are again selectively *connected* by different scale-articulated networks. You can say something similar of devices, networks, organs, organisms and organizations, although very different scale-articulated differences play a role at fewer or even more levels of scale.

This 'order' is only a kind of equality (approaching the limit of difference) on a subsequent scale level. The fact that different differences (eg equality) are noticed at different levels of scale, with different resolution, does not surprise me.

There are many more levels of scale between 'microscopic' and 'macroscopic', than to which physics (mechanics, thermodynamics, relativity and quantum mechanics)[e] is limited per discipline. Ecology should distinguish at least 15 levels of scale in order to define biodiversity.

A change of scale can reverse the conclusion 'order' or 'disorder' already by a factor of 3 (***Fig. 6*** p18). Without scale specification you can conclude both in the same time.
I know only one publication that divides 'complexity' into different levels of scale and then partly concludes 'entropy'.[f]

I know from experience that change more often destroys difference than creating it. My footstep full of information on the beach is lost in the sea by advancing and retreating seawater, but a remaining jellyfish changes less. That counts as long as its

a Page(2011)Diversity and complexity(Princeton)University Press p32 See also Prigogine;Stengers(1984)Order out of Chaos Man's new dialogue with nature(London)Flamingo, Gleick(1987)Chaos making a new science(New York)Viking
b Simon(1969)The Sciences Of The Artificial(CambridgeMass1982)MITPress p3: '…complexity, correctly viewed, is only a mask for simplicity…'
c Haken(1978)Synergetics an introduction(Berlin)Springer
d Portugali(1999)Self Organization And The City(Berlin)Springer; Batty(2007)Cities and complexity(Cambridge Mass.)MIT Press
e Young(1964)Fundamentals of Mechanics and Heat(New York)McGraw-Hill
f Bar-Yam(2004)Multiscale Complexity/Entropy(Cambridge, Mass)

protective walls and internal membranes do not lose their separating effect and its internal differences do not fall prey to the great environmental equalizer: entropy.

In a cylinder with molecules (1) and empty spaces (0) the entropy of an unequal distribution 111000 also increases into an equal distribution 101010.
The first is accumulation (compression), the other is dispersion (expansion).
This 'equalizing', conceived as characteristic of increasing entropy, seems to contradict the Shannon entropy.

In ***Fig. 176*** p200, 111000 and 101010 have the same maximum information entropy, but from both into 111111 (equality) that entropy actually decreases.
The 'Kolmogorov complexity' of 111000 (with the shortest calculation rule '3 times ones and 3 times zeroes') is also greater than 111111 ('6 times ones').

The sequence 101010 seems to be in between ('3 times (one and zero)').
In all cases it must be explained what concepts such as 'calculation rule', '3', '6', 'times', 'and', '(', ')' *mean*, but Kolmogorov claims to have proved that another language than this vocabulary does not matter for its complexity (language invariance).

The size is the same (6 characters), but a supposed level of scale has two boundaries: not only an external boundary ('frame'), but also an inner boundary ('grain') with which the resolution (grain/frame) is determined.
At the smallest grain scale (A) you have an alphabet of two characters (0 and 1). You recognize one difference in 111000, five differences in 101010 and zero in 111111.

If you double that grain scale (B), you will see 11 10 00, 10 10 10, and 11 11 11 recognizing 3 characters (11, 10 and 00) and thus only 2 differences in the first bit range. Now take a grain scale C. You see 111 000, 101 010 and 111 111. You now recognize 4 characters (111, 000, 101, 010) and you recognize only 1 difference in the first two cases (***Fig. 181***).

bit range	Shannon entropy H	Kolmogorov complexity	grain scale A 2 characters differences	grain scale B 3 characters differences	grain scale C 4 characters differences
111000	1	high	1	2	1
101010	1	medium	5	0	1
111111	0	low	0	0	0

Fig. 181 Differences in a bit range differ per supposed level of grain scale

This exercise is not intended to find any regularity in this list, but only to prove that other differences can be observed and named on a different scale.

As a result, scale paradoxes can occur (***Fig. 6*** p18).
It is also an example of the first part of the definition of complexity that I have presented above: 'different differences at different scales'. If you find differences on a certain scale, but on the following scale 'zero difference' (equality), then there is a pattern, an order like 101010. But 'order' is not yet 'organization'.

The final section of my definition, '... that change less than their environment', adds the relative stability that is characteristic and necessary for what 'complexity' seems to mean.

Differences are defended against the externally omnipresent equalizing entropy, and maintained by separation.
Separation consists of two differences, more or less symmetrically mirrored, such as in walls, cell walls, membranes, but also in legal rules.

Separations themselves change less than their environment by static connection ('zero separation') ⊥ to the separation direction, so that (once separated) the external differences also stabilize. A different set of separations and connections ('structure') is crucial for organizations, organisms, organs, networks and devices.
Separations are required for their creation and maintenance, connections are risky.

The contradiction between the physical ('Clausius') entropy and that of Shannon, in which the one takes equality as a hallmark of disorder and the other on the contrary of order, is partly solved by different resolution.
There are, however, more differences in their assumptions.

With Shannon it is chances of a next character in a linear, one-dimensional bit series. With Clausius, macroscopic chances apply on three-dimensional states.
These chances may differ in 6 mutually ⊥ standard directions. The macroscopic degrees of freedom may differ in those directions. This is the case, for example, in a closed cylinder with a piston that allows only freedom of expansion into one direction.

If you build a two-dimensional screen picture by dividing a byte sequence into horizontal lines and displaying them in time one below the other, then the Shannon sequence only applies horizontally, but not vertically.

For the device, there is no vertical relationship between the pixels in the message. That connection must be made by the spectator. A vertical streak supposes a vertical equality, but it requires a horizontal difference (***Fig. 5*** p17).

There is a perpendicular paradox that is invisible in the tube vision of a bit sequence. This paradoxical effect becomes only stronger with a third dimension that adds two directions and perhaps also with a fourth dimension (time) that adds one to it again. This makes the case 'complex' and difficult to 'describe' (linearly).

It is therefore quite possible that you see order where another sees disorder, not only through a scale shift, but also by changing direction or spatial and temporal order. They are then summarized in the confusing term 'complexity'.

§ 36 PHYSICS SUPPOSES A DESIGN

Fig. 7 p24 distinguishes modalities, levels of scale, context layers and object layers of design. Physics then exhibits the following design features.

Modality ⇓ ((true⇒probable⇒possible⇒imaginable**)**∧desirable**)**
Truth is limited by the number of decimals that can be measured with the tolerance of measuring instruments. So 'truth' has a tolerance. If small deviations of initial values have great effect by iteration, then the predictions are not necessarily 'true'.
That is well-known from the weather forecast.

Newton's design of mechanics is a high point in physics, but the mechanics of a large number of masses (eg molecules in a m^3 of gas or celestial bodies in the universe) is unmanageable. All their individual initial states should be measured simultaneously and each should get a place in a mathematical form. You are forced to take averages.

Moreover, the change of scale forces to use other variables than distance, time and mass (eg volume, pressure, temperature and entropy).
It led to the dethroning of determinism in favor of **probability**.
Thermodynamics does not replace mechanics, but supplements it at a different scale.[a]

Light as particles (Newton) or as waves (Huygens) covers an alternating truth.
This is reminiscent of the perpendicular relationship between an electric and a magnetic field, and the perpendicularity paradox on p16. It comes across "The insufficiency of language"[b], perhaps struggling with its meta-language.

It does no longer concern conflicting '*qualities*', but alternating *behaviour* (with other variables and operations), *operating* on us as observers, and even affected themselves by our measurements.

The search for truth passes many **possibilities**, sometimes rejected by falsifications (experiments), sometimes leading to mathematical forms, no longer **imaginable** as real objects as we are used to, at the human scale in space and time.

Levels of scale ⇓ (…,10m,3m,1m,…)
The spatial levels of scale are beautifully portrayed[c], and those of time even better[d].
The variety in these images is phenomenal, worrisome.
The relations that mathematics constructs between them creates some peace, but the unrest remains, and motivates to stay in the study room behind a screen for years.

The space that seems accessible to us extends from 10^{-15} to 10^{25} meters, the time from 10^{-44} to 10^{100} seconds.
At the limits of the universe, however, the light, apparently limited by its speed, shows stars only until 13.7 billion light years ago. At that maximum speed we would only

a Young(1964)Fundamentals of Mechanics and Heat(New York)McGraw-Hill
b Wilkinson in (1959)Turning Points in Physics(Amsterdam)North-HollandPubCo p149 e.v. in the Dutch version
c Boeke(1957)Cosmic View(New York)John Day; Morrison (1982)Powers of ten(New York)Freeman and Company, shows 42 spatial levels of scale.
d Nobelprizewinner 'tHooft(2011)Tijd in machten van tien(Diemen)Veen Magazines followed the example of Boeke showing 48 temporal scale levels.

arrive there after 13.7 billion years. That is also almost the supposed age of the universe ($10^{17.64}$ seconds).
Living 100 years ($10^{9.5}$ seconds), is an unnoticeable flash in history.

The shortest life span of subatomic particles is 10^{-16} seconds.
We cannot distinguish this lifespan, not even as a trace in any medium. We can only calculate that they must 'exist'. The fastest chemical reaction requires 10^{-13}, our eyes only distinguish $10^{-1.2}$, our ears at most 10^{-4} seconds. A cesium clock distinguishes $10^{-9.96}$ seconds, but a signal of that duration has no communicable beginning and end.

In quantum mechanics mathematics leads to unobservable objects, ghostly figures that are as unimaginable as an unnoticeable flash of human life seen from the Big Bang. You assume that they must 'exist'.
They anyhow deliver physics a proven predictive ability and technical applications.
In order to unite this branch of physics with that of the theory of relativity probably requires unimaginable dimensions beyond the 4 we already know on our scale.

The probability theory includes the domain of deterministic mechanics at two boundaries in the scale series. From the atom to the largest solids (particles that move together) *mechanical* mathematics is applicable. The *thermodynamics* of many freely moving particles require other variables and operators. This became also necessary for modeling subatomic particles, beyond the lower limit of classical mechanics.

Context layers⇓(Abiotics⇑Biotics⇑Technique⇑Economy⇑Culture⇑Governance)
Abiotic connections between atoms (chemistry) became better understood by the quantification of electron shells around an atomic nucleus (physics). In general, *connecting* delivers energy ('exotherm'); *separating* costs energy ('endotherm').

A chemical reaction is often a combination of both (***Fig. 183*** p219).
If the free energy from the new connection 'pays' the next separation of its components, the reaction proceeds. If not, there must be energy added from outside.

In order to *initiate* such a chain reaction, the first separation (to release components from connection) must receive energy from outside (inigtion, the invention of fire!).

The following exothermic connection then provides the energy for the next endothermic separation. The binding energy that must be overcome in a reaction differs per molecule. The physical environment has already formed the most likely compounds since the earth's formation (such as CO_2 in the atmosphere).

Biotic processes are less probable than abiotic ones. They take place in cells, separated by selective membranes from the more likely physical outside world. These select inward unlikely and outward likely material[a] ('metabolism').

a By 'material' I mean not only mass, but also energy and information.

This makes these processes (including reproduction) possible. As a result, they locally reduce the entropy (increase the improbability) at the expense of the outside world. That is probable on a larger scale, but improbable on the small scale.

Within a cell there is a multitude of inner worlds separated by membranes.
The arising differences cannot be modeled only as a deviation from an average.
There are many variables whose values differ from averages, while they make the difference between inside and outside ('life'). The mathematical modeling of these is therefore more laborious than in the abiotic outside world on that scale (0.3-3μm).

These internal membranes separate and connect selectively ('selectors' in different directions, ***Fig. 10*** p28). These make the mechanically rather fixed structure that controls chemical processes. They can basically be modeled mathematically, but their diversity is too great. The kinetic, thermodynamic and chemical processes have an even greater variety on different levels of scale (cell, organ, organism, organization).

Technique applies Abiotic and Biotic models, upscales them, and invents new ones. It has, however, not yet reached the possibilities of existing biotic mechanisms by far. Their *technique* is still not part of our *technology*.
New 'inventions' are often derived from biology ('biomimicry', 'ecomimicry').

Techniques of survival, however, have given rise to invent models of physics in order predict and improve the effect of our actions.
The most impressive example is Archimedes of Syracuse (287-212BC), inventing defence weapons for his city[a], the screw for pumping water, calculating the effect of a lever, measuring volumes of irregular bodies, forerunner of calculus.

Economy is a kind of metabolism summarizing individual actors with their own wishes and expectations. An economic (infra)structure of connections and separations optimizes the metabolism between extraction and consumption.

Reduced to physics, concentrated stocks 'm' must be distributed into the consumers over a distance s or space s^3 with ms (transport) or m/s^3 (storage) as a result.
The time t delivers mt (physical capital) or m/t (production, consumption).

So far, the abiotic component of economy is mechanically modeled, but the mechanical mass differentiates in different qualities (as distinguished in chemistry and biology by different molecules, atoms and compounds with each their own name).
Mass should be split and transformed into m_1, m_2, m_3 and so on. In the change of those *different* masses (production) *different* 'biological' and 'technical' models fit.

The different masses m_1, m_2, m_3 ... in economy, however, also represent a 'value' v in vm_x that through actors can vary according to their wishes and expectations. Space and time also represent a value vs^3 and vt. The time can be split into working time,

a Plutarch(AD 46–after 119)Parallel lives of noble grecians and romans. In the life of Marcellus http://classics.mit.edu/Plutarch/marcellu.html (one of the 46 lives described by Plutarch) Archimedes is described as saviour of Syracuse by his defence machines defeating the Roman army of Marcellus. That probably exaggerated part you can find in http://www.math.pitt.edu/~sph/osher-course/plutarch-on-archimedes.pdf production time, waiting time and so on. This brings new uncertainties beyond the probabilities of abiotic and biotic quality. That is the own object of economic science.

Culture encompasses even more than such 'values', namely tradition, customs, habits, commandments and prohibitions, different on different locations.
It is mainly the *information* content that, durably and largely unspoken, enables or limits human actions and thus also economy and technology.
A physical, biotic, technical and economic context and their history determine the limits of culture, but that is already enclosed in the *conditionality* of context layers.

Governance is also mainly determined by its information content and less by other physical qualities. The executive component has physical sides, but these are chosen under administrative influence and determined by underlying context layers.

Object layers ⇓ (Content ⇑ Form ⇑ Structure ⇑ Function ⇑ Intention)
Let us this time reverse the sequence of enabling (⇑) into required suppositions (⇓).

Abiotic conditions have no **intentions** (as far as I know), but they do suppose functions, structures, forms and contents. They can arouse the intention in humans to *understand* sun, wind, water and soil, with or without the further goal of *using* them as means to survive. The use of that understanding, however, has inspired great contributions to physics, but its purest motive is bewilderment and curiosity.

Between curiosity and use lies the experiment, a design to get a grip on (understanding of) the **function**, the functioning, the operation of reality.

This often separates a part of that reality in a laboratory to exclude incident input such as a disturbing light source in an observatory.
This way one isolated effect of x on y becomes clear. Insofar as both are quantifiable. It can be formulated as a mathematical function y=f(x).

In reality, however, many functions are operating at the same time.
They influence each other's functioning, as different force fields can influence the same object. This then happens in a **structure** of functions that are separated or connected. In order to gain some understanding, you can design a structure (model, instrument) in which different functions work alongside or after each other.

This supposes, however, a spatial dispersion of functions (including the static functions of separation and connection: selectors such as bowls, tubes and valves that control the dynamic functions): a **form**.

In some design disciplines, the form seems to be of little importance.
If the intended structure has the right topological constellation, then it can work in different forms, but for the realization at last you have to choose one form.

The **content** of an abiotic object is, due to its mathematical basis, the set of variables used by physics. Chemistry distinguishes different types of mass (biology even more), but quantum theory does that subatomically as well. Chemistry is then inter-atomic physics. The distinction lies in the scale-dependent content.

8 ABIOTIC CONDITIONS ARE PROBABLE

PHYSICS CAN BE CONSTITUTED

Is physics constitutable according to ***Fig. 13*** on p37? It reads:

A difference	⇑ change	⇑ coherence	⇑ selection	⇑ combination	⇑
B metabolism	⇑ regulation	⇑ organization	⇑ specialization	⇑ reproduction	⇑
C information	⇑ security	⇑ affection	⇑ identity	⇑ influence	

Location, time, velocity and direction do not have a fixed frame of reference by nature, no coordinates with a fixed direction and a fixed location as an origin.
There are only ***differences*** of direction, place, time or speed.
The perception of a difference, makes orientation possible in the *direction* of the difference or ⊥ thereto (***Fig. 5*** p17).

Change ⇓ a difference (with 'now'). Change contradicts a prior image (like succesive photographs stacked on a pile). That contradiction is solved by considering time to be ⊥ any spatial dimension. Variables get an index (as vectors $\mathbf{v}_x \perp \mathbf{v}_y \perp \mathbf{v}_z \perp \mathbf{v}_t$), adding different directions as different *qualities* to their name.

Logical (linear) contradictions then do not have to contradict in multidimensional space (§ 21 p105). Just as difference has its limit in equality, change has its limit in remaining, staying or 'duration'.

Coherence ⇓ difference in change. Coherence distinguishes solid matter (on which the mechanics applies also on a larger scale) from gas (on which thermodynamics must release its probability). They differ in less or more change. A fixed structure limits the freedom of movement of liquids and gases. Structure controls their operation by 'separation' with 'connection'[a] as a limit or zero value (***Fig. 9*** p27). Objects can be separated always more (eg by distance), but not always less.

Selection ⇓ difference in coherence.
A window in a wall is a connection ⊥ the separating quality of the wall.
The wall separates, but the window connects as a selector (the sieve in ***Fig. 10*** p28, for example selecting light, but no heat or wind). Membranes play a primary role in biotic conditions. The limit or zero value of selection is mixing.

Combination ⇓ difference in selection.
With this the field of chemistry is constituted. Connections are separated, and selected components are exposed to each other in order to form a connection.
Separation is the difficult part.
You can mix sugar in the coffee, but getting it out again takes more effort.
There are, however, unlikely organs and organisms to do so.

Metabolism ⇓ difference in combination
The next chapter elaborates the biotic layer, starting with the chemistry of metabolism.

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a In everyday communication 'connection' has both a static (cables, screws or nails) as well as a dynamic (access-leading line or road) meaning. Here I intend the dynamic meaning.

The improbability of organisms and their emergence is an important argument for those who do not believe in evolution.
The long *time* in which evolution any second has taken *place* in countless microscopic locations, and the infinite number of exceptional circumstances where unlikely processes may have occurred are unimaginable indeed.

The *diversity* in which life has subsequently developed into the present reality cannot be imagined either.[a] It is based on exceptional 'mistakes' in the reproduction ('mutations') without which we would have remained unicellular or even less.

Evolution is not a deterministic process on which predictions can be based.
It withdraws from the probability account with numerous exceptions.
Nevertheless, a process of iterations (p150) takes place after each mutation, which can be followed with current science. This chapter only gives an impression thereof.

This science enables us to *cause* mutations. It has, however, still not been possible to design the context in which life emerges from abiotic components.

a Dawkins(1996)Climbing mount improbable(London)Viking

9. BIOTIC CONDITIONS ARE IMPROBABLE

§ 37 LIFE USES PREDOMINANTLY 12 OF THE 118 KNOWN ELEMENTS

THE IMPROBABLE DIVERSITY OF LIFE IS POSSIBLE WITH 12 COMPONENTS

The elements once discovered are numbered in a 'periodic system' from 1 to 118.
A living organism mainly uses the numbers 1 (H), 6 (C), 7 (N), 8 (O), 11 (Na), 12 (Mg)), 15 (P), 16 (S), 17 (Cl), 19 (K), 20 (Ca), 26 (Fe).

These 'atomic numbers' represent the number of 'positively charged' (+) nuclear particles ('protons') in the core ('nucleus') and usually also the number of 'negatively charged' electrons (−) that, rotating in a cloud neutralize the positive charges.

The same element may contain a variable number of neutral core particles without charge ('neutrons'). It then has different variants ('isotopes') with a different atomic weight ('atomic mass'). The atomic mass is therefore not exactly related to the atomic number, but you may conclude that in living organisms only light atoms play a role.

You can determine the number of atoms or molecules in a gram of pure substance with the 'atomic mass', or the 'molecular mass' that can be derived from it.

If you take the number of grams of that substance that corresponds to the mass number per particle ('grammol' or simply 'mole'), then one mole always contains $6{,}02214 \times 10^{23}$ particles ('Avogadro constant').

The outermost electrons of atoms make chemical connections possible

Electrons behave on the one hand as particles and on the other hand as diffuse waves ('quanta'). They move around the core in a cloud, but they are locked up and separated into different 'shells' at different distances from the core.

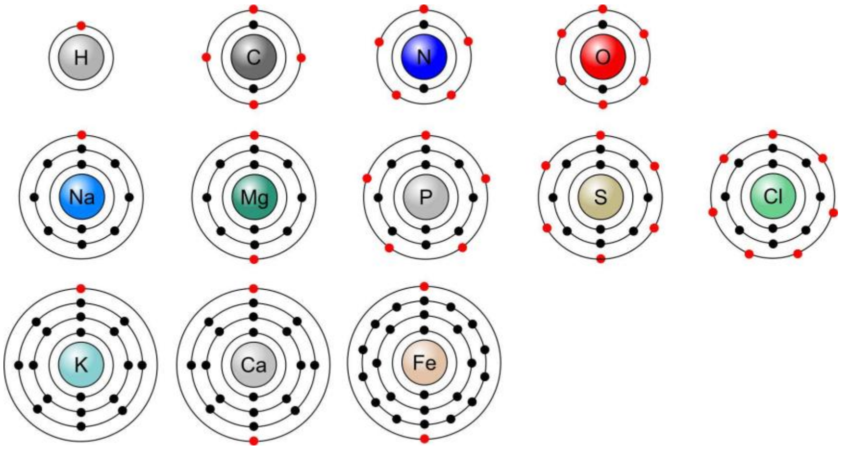

Fig. 182 Elements most present in living organisms with their electrons per shell[a]

The first four shells have a maximum of 2, 8, 18 or 32 electrons from the inside to the outside. They repel each other by the same negative charge, but they also have more space in the larger shell and they follow different paths to avoid each other.
A further classification of these peels ('quantum paths') is left out of consideration.

a https://en.wikipedia.org/wiki/File:Periodic_Table_of_Elements_showing_Electron_Shells.svg

In pairs, electrons endure each other by turning around their axes against each other as gearwheels (with opposite 'spin'). Their number per shell is therefore preferably an even number. The greater the distance to the core, the greater is their potential energy.

If an electron falls back into an energy-porer layer where is still space ('unsaturated shell'), the lost energy is emitted as a radio wave with a characteristic wavelength, for example an atom-characteristic colour of light. The other way round, radio waves may push up electrons into a higher shell or break a connection with other atoms.

Hydrogen (H, atomic number 1) is the lightest element with one proton (H^+) and one electron (e^-). In ***Fig. 182*** iron (Fe, number 26) is the heaviest, with the most electrons (26), distributed over 4 shells with 2, 8, 14 and 2 electrons. There are still 92 heavier atoms with more shells that are not welcome in living organisms (often 'poisonous').

The electrons of the outer shell (marked in red) are attracted the least through the core. They are relatively loose and can choose another atomic nucleus in the neighborhood. They are then involved in the connection between the atoms into molecules.

A chemical reaction involves relinquishing or sharing electrons from an unsaturated outer shell.

CONNECTIONS COMPENSATE SHORTAGES IN THE OUTER ELECTRON SHELLS

Unsaturated atoms are electron attractors

'Noble gases' such as He (2 electrons) Ne (2, 8), Ar (2, 8, 8) and Kr (2, 8, 18, 8) hardly react with other atoms. Their outer shell is 'saturated'.

Every other atom is unsaturated in the outer shell, inclined to supplement it into such a 'noble gas formation'. A lonely 'unpaired' electron makes them even 'radical'.
O (2, 6), N (2, 5) and Cl (2, 8, 7) have a great attraction to electrons from other atoms (being 'electronegative' or 'acid'), eager to 'oxidize' them.

Ions are charged, attracting opposite charges into a bipolar ion binding

A small atom can lose electrons to a larger atom with more attraction.
With each electron too much or too little to be neutral, an atom or molecule as a whole (in that state a 'ion') has a negative (-) or a positive (+) 'charge'.

Two oppositely charged particles attract each other. A small atom can therefore be 'slavishly' bound to the large atom and remain combined ('ionic bond').

The position of the large atom in the resulting molecule as a whole ('locus') then becomes more negative than the locus of the smallest, so that the molecule gets a negative and a positive pole ('bipole'). They therefore tend to seek contact with opposing loci in the environment with a similar head and tail (-) and (+).

The acidity pH represents the number of H^+-ions without electron

Water molecules (H_2O) with their H^+H^+ and O^{--} poles are strongly bipolar.
They can penetrate and detach the ionic bond of other bipolar molecules so that these 'dissolve' into two separate ions. Loose hydrogen ions (H^+-ions without electron, in

fact protons) make the solution acidic. The 'acidity' is a measure ('pH value') for the number of H^+ ion moles per liter in a solution.

This number can vary from 1 mole H^+ per liter (eg the extremely acid hydrochloric acid H^+Cl^-) to 0.000 000 000 000 01 mol per liter (eg the extremely basic sodium hydroxide Na^+OH^-).

The Ph value only shows the 'number of zeros' (negative logarithm), in a scale of 0 to 14 (from 10^{-0} to 10^{-14} mol/l H^+). Up to 7 you call the solution 'acid' otherwise 'base'. Differences in pH, charge or potential, play a major role in biology.

O^{--} is too radical to stay alone, but less negative ions such as OH^- neutralize acid (H^+ ions) producing neutral water H_2O. With a majority of OH^--ions or electrons (pH greater than 7) the solution is 'basic'.

According to Lewis, an acid is a molecule that can *absorb* an electron pair; a base can *donate* an electron pair. Deviating from this 'Lewis definition' you may also consider a loose proton (H^+) as the smallest acid.

Covalent bindings are strong; hydrogen bonds are weak
Elements can also complement their outer shell by using an electron pair together ('covalent bonding'). For example, a salt is the connection of an acid residue with the electron pair (--) of a basic residue (++).

The number of electron pairs that an atom misses and can supplement with a different atom to a noble gas formation is called 'valence'.
This 'fair' covalent bond is stronger than an ionic bond.
Such a bond only arises when atoms are pressed close enough against each other to bring electrons from one atom under the attraction of the other core.

During that 'falling upon each other', energy is *released* ('free energy').
Breaking a connection *costs* the same 'binding energy'.
At a short distance, physical 'van der Waals forces' also have a binding effect.

Finally, hydrogen between two molecules, or between two loci within one large molecule, can also share its electron with both molecules ('hydrogen bridge').

This gives a weak, fragile, elastic connection that can easily be broken by increasing distance. For example, a DNA string consists of two very long firmly covalent bound molecules that are mutually linked by hydrogen bridges.
For cell division, they are easily pulled apart without breaking themselves.

Connection delivers energy; separation costs energy (usually)
If you light methane gas CH_4 with 2648 kJ/mole energy, then you you break its connections and also some of its surrounding oxygen. The hungry (electronegative) oxygen atoms (O) in the vicinity are ready to connect with the carbon and hydrogen of the weakly bound CH_4 to the strongly bound ('more stable') carbon dioxide (CO_2) and water $2(H_2O)$.

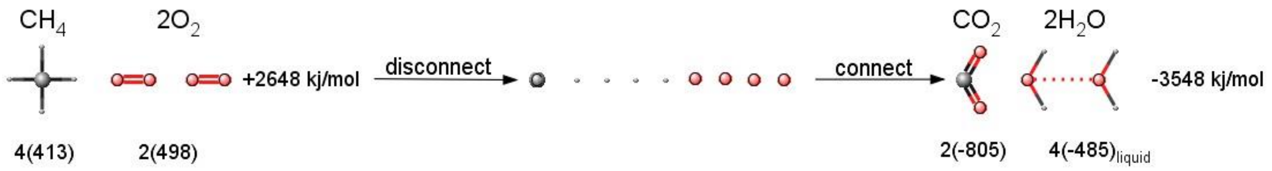

Fig. 183 A chemical reaction disconnects and connects

The required disconnection energy is written as positive input (+) and the released energy by connection as negative output (-). An external *profit* is internal *loss*.
So you write: CH_4+2O_2+2648kj/mole → CO_2+2H_2O-3548kj/mole.

The separation does not require more energy (+2648kj/mole) than the energy production (-3548kj/mole) from 'more stable' connections, otherwise the reaction will not continue. It is enough to OXidize the next methane molecule ('ignition', a chain reaction). The oxygen is then REDuced ('REDOX reaction')[a].

There are lists of (un)binding energies for each compound under 'normal' atmospheric conditions (25°C and 1 bar pressure)[b], for example: disconnecting C-H costs 413, O=O 498, C=O in carbon dioxide 805, O-H in liquid water 485 kj/mole.
That is the energy that you need to separate, but also the energy that is released when connecting (***Fig. 183***).

When all methane is burned, 4(413)+2(498)-2(805)-4(485)=2648-3550≈-900kJ/mole of heat is thus extracted from the reaction ('free energy' or better 'enthalpy','ΔH').[c]
Living organisms prevent such an explosive chain reaction in order not to burn themselves. They realize the reaction step by step.

Separation usually costs energy, but separating P-O-P ('diphosphate'), ***delivers*** energy. Any living cell uses this opportunity to stay alife. Energy gained from photosynthesis or food is immediately stored in 'ATP' (with a high 'energy level', but less 'stable', see ***Fig. 195*** explained on p225) and distributed without loss of useless heat.

Such ATP molecules then must be able to load, transport and unload a small package of energy easily again and again, in order to *deliver* energy ('exotherm' or 'exergonic') required for all other ('endotherm' or 'endergonic') organic reactions *using* energy.

Their loading point is the 'mitochondrium', present in nearly any cell, burning sugars made by vegetal photosynthesis elsewhere. In step by step reactions (keeping equal temperature and pressure) you the released energy is not 'heat', but 'entalpy'.

Pressure from outside brings the atoms closer together and strengthens their bonding. So, at higher pressure the required (un)binding energies increase.
Higher temperature, however, also increases their potential energy, and confronts the molecules with more collisions. In doing so, they run the risk of both binding and decomposition. That balance is different for each connection.

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a Clark(2010)Bond enthalpy(Cambridge)International http://chemguide.co.uk/physical/energetics/bondenthalpies.html .
b http://www.wiredchemist.com/chemistry/data/bond_energies_lengths.html , https://labs.chem.ucsb.edu/zakarian/armen/11---bonddissociationenergy.pdf
c The calculation can be more complicated than is important here for global understanding, see Ellison(2002)Bond Dissociation Energies of Organic Molecules(Boulder)University of Colorado http://www2.chemistry.msu.edu/courses/cem850/handouts/Ellison_BDEs.pdf

Life is based on a simple energy cycle

Plant organisms can use energy from sunlight ('photosynthesis') to get the C back out of the strong oxygen grip of the CO_2 in order to produce their own C-H compounds (CO_2+$2H_2O$+solar energy → CH_4+$2O_2$-heat).

This carbon capturing process would eventually remove most CO_2 from the atmosphere and limit plant growth unless a counterbalancing force would bring C back in the atmosphere again. Animals are such a counterbalancing force.

Animal organisms subsequently oxidize (with the released oxygen) the carbon compounds from plants into CO_2 before this vegetation disappeared as fossil fuel into the soil (CH_4+$2O_2$+2648kj/mol → CO_2+$2H_2O$-3548kj/mol).
As easy as you can describe this 'carbon cycle' on a global scale, as complicated it appears to be step by step in a cell.

§ 38 CARBON CONNECTS

CARBON CONNECTS WITH HYDROGEN (H)

Carbon plays the main role in living organisms. A carbon atom can connect with 4 bonds (has 4 'valences'). In a chain of (single bounded) carbon atoms, the intermediate atoms have 2 valencies left, at the ends 3.

Those residual valencies are usually occupied with hydrogen (H).
Such strings are known as 'hydrocarbons'. The occupation with H-atoms is so general, that they often are omitted in drawings[a], in order to keep overview.

In ***Fig.*** 184, the chains of 1, 2, 3, 4, 5 or 6 carbon atoms (C_1, C_2, etc.) are named.
The first column contains the 'alkanes' 'methane' (CH_4) to 'hexane' (C_6H_{14}).
At C_6, the chain can also form a hexagonal ring 'cyclohexane'.

If such a ring has 3 'double' bonds, then it is called 'benzene', a member of the 'alkenes' in the third column. The fourth column with triple bonds are 'alkynes'.
Molecules with double or even triple bonds are called 'unsaturated'.

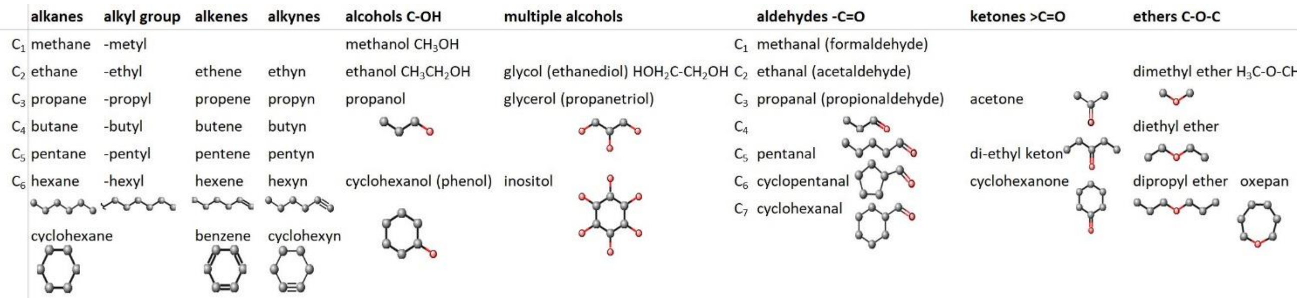

Fig. 184 Hydrocarbons ***Fig. 185 With oxygen***

CARBON CONNECTS WITH OXYGEN (O)

An H-atom can be replaced by a 'hungry' oxygen atom.
The hydrocarbon rest is called 'alkyl group', in the name of the whole indicated by '-metyl', '-ethyl' and so on. The new molecule could then be called 'oxygen-methyl' or 'oxygen-ethyl', but oxygen can also claim *two* valences (double bond).

Therefore, these different compounds each have got their own name (***Fig. 185***), ending with -ol (alcohol, single bond) or 'al' ('aldehyde', double bond).
If an intermediate C atom has a doubly bound =O appendix, then it is a 'ketone'.
If an intermediate C atom is replaced by an O atom, then you speak of 'ether'.

Sugars are multiple alcohols

The multiple alcohols in ***Fig. 185*** have important variants called "sugars" (***Fig. 186***).
Some (eg glucoses) have the same formula, but a different spatial structure ('isomers') with a different behaviour. Glucose is usable as a human nutrient, but a polymer with glucose as component (cellulose, a building material in plants) is not.

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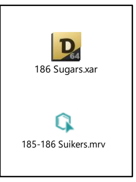
a I have largely drawn the molecular figures with the freely downloadable computer program ChemAxon's Marvin sketch.



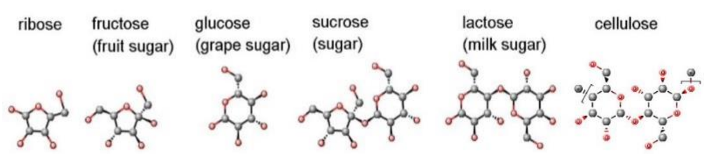


Fig. 186 Sugars (saccharoses)

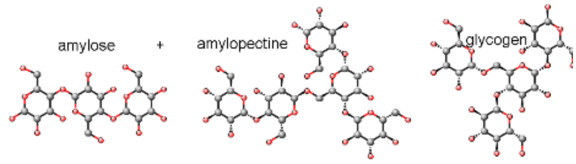


Fig. 187 Starch and glycogen

Agglomerated sugars (***Fig. 187***) are formed in plants ('starches') or animals ('glycogen') as energy storage.

Fatty acids have a -COOH group

If two oxygen atoms claim all 3 remaining valences from a C-terminus, then they form with that C-atom the acid-making 'carboxyl group' (-COOH, a combination of a 'carbonyl group'>C=O and a 'hydroxyl group' -OH).
Alkyl groups from ***Fig.*** 184 with –COOH are 'fatty acids' (***Fig. 188***).

Three of them connected by a glycerol molecule (***Fig. 185***) it is 'fat' or 'oil' (***Fig. 188***).
From a fatty acid you can also make an 'ester' with a carbon atom on the other side.
With Sodium$^+$ (Na^+) as a ion-bound 'cation', a fatty acid$^-$ (an electron-consuming 'anion') becomes a soluble salt ('soap').

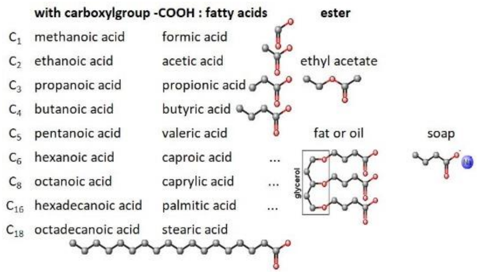


Fig. 188 Fatty acids and their esters

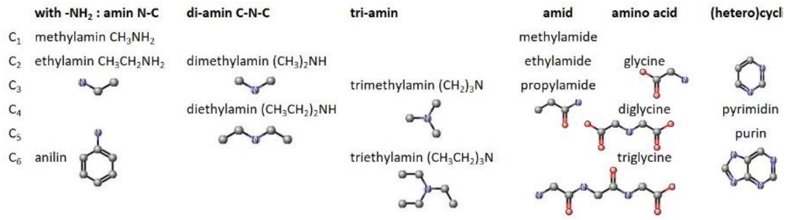


Fig. 189 Amins, amids, amino acids and cyclics with N

CARBON CONNECTS WITH NITROGEN (N)

Proteine is a combination of 50 to 3000 amino acids in a sequence of 20 types

If you replace a C-atom of a C-chain (alkane) with an N-atom (***Fig. 189***), you can get 'amines' or 'amides', often reacting as a base.
If the last C-atom in the chain is an N atom, and you replace the first with an acid carboxyl group (-COOH), then you have an acid with a basic N-tail ('amino acid').

The smallest amino acid is $C_2H_5NO_2$: 'glycine'.
Two amino acids can be joined with head and tail to form a 'peptide'. This takes little energy and some water is released (H_2O, shown as an O-atom in ***Fig. 190***, the 2 H's are omitted). Long chains ('polymers') of peptides you call 'protein' (see ***Fig. 191***).[a]

Connections have a preferred angle. If that angle always has the same turning direction, then the polymer gets a spiral shape (***Fig. 191***).

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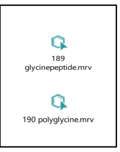
a http://proteopedia.org/wiki/index.php/Proteopedia:Table_of_Contents is a wonderful educational program that explains in 3D moving images which connections exist within proteins and how they work.



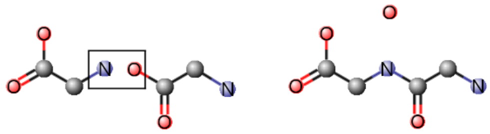


Fig. 190 Two glycine molecules producing a peptide

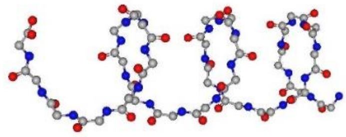


Fig. 191 Glycine polymer as long protein spiral

Fig. 192A shows 20 amino acids that play a role in living organisms in the order of their size.[a] Their names are usually limited to abbreviations with 3 characters.

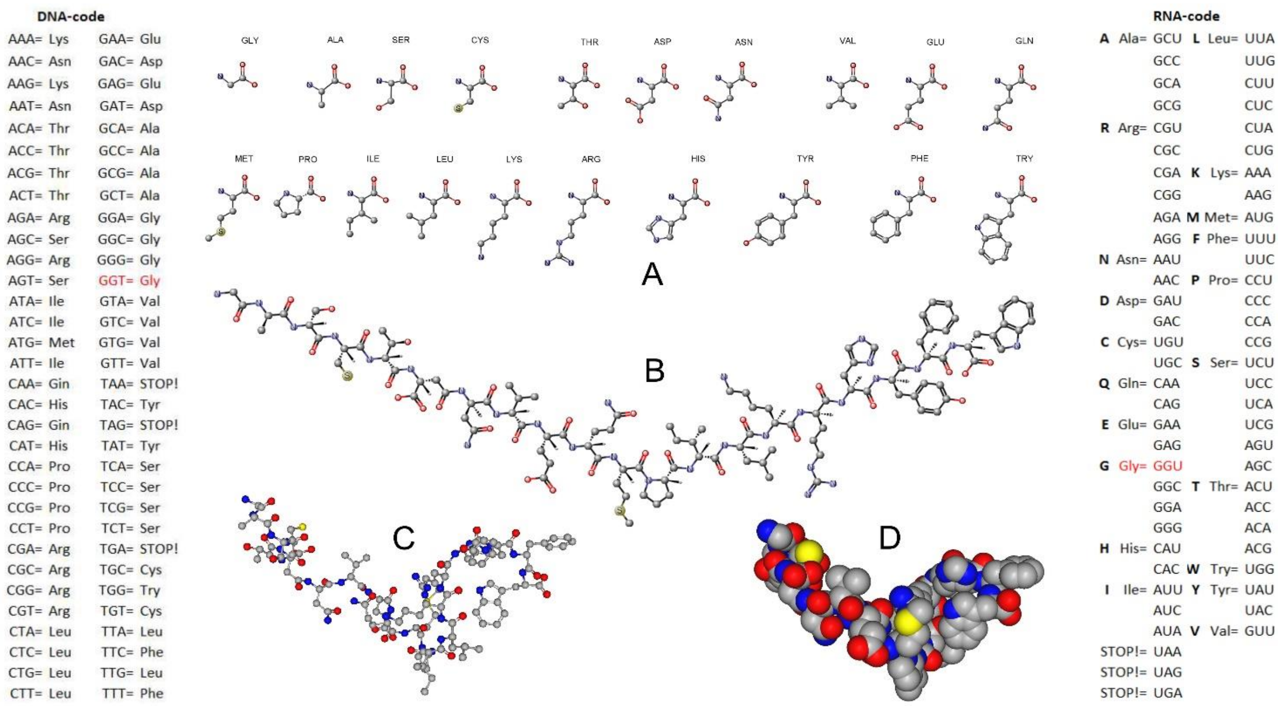


Fig. 192 Twenty amino acids in order of size (A), strung together (B, C, D) to an imaginary protein. On the sides the DNA and RNA codes (codons) with which they are made.

In ***Fig. 192***B an imaginary protein is constructed from those 20 amino acids in the same order. With different angles between the connections and due to mutual attraction, such a long chain never remains clearly stretched, but in all kinds of bends it folds into the same tangle.

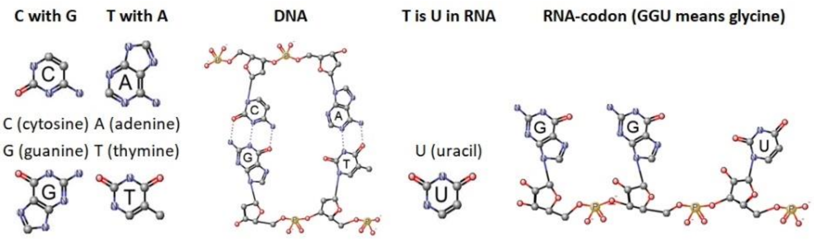
This shape is then characteristic of each protein (***Fig. 192C***). ***Fig. 192***D shows the size of the atoms with their repulsive electron clouds and the shape of the folded molecule in a more realistic way. This form can be crucial for mutually fitting interactions with other proteins or compounds.

About 100 000 different proteins are known in the human body, each with its own form and function. On the internet you will find a huge database.[b] Each protein contains about 50 to 3000 amino acids in a unique order.

a With a few newly found rare amino acids, there are 22.
b http://www.rcsb.org/pdb/home/home.do

DNA names each amino acid by three characters

For example, 'GGT' (a 'codon' or 'triplet' ***Fig. 192***) in DNA language means 'Glycine'. The amino acid sequences of any required protein are listed in parts of its DNA, an identical unique library, present in the nucleus of every cell of one unique organism.



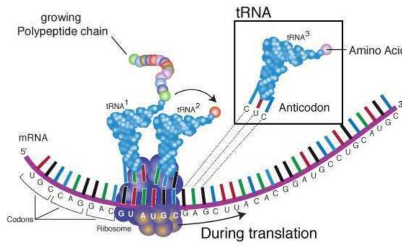


Fig. 193 **The alphabet of DNA and RNA** ***Fig. 194*** **The production of a protein**[a]

DNA has an alphabet of 4 characters (the atomic groups Thymine, Cytosine, Adenine and Guanine, usually coded with T, C, A and G, see ***Fig. 193***).
Proteins are kept together by a simple 'peptide bond', but DNA keeps its codons in sequence by a 'backbone' of sugar and phosphate.

This way, a visitor to the DNA library can copy the prescription for every protein. Such a copy is a long molecule 'mRNA' ('messenger RNA').

That copy uses the same alphabet as the DNA, but in RNA language (U, C, A and G) Thymine (T) is replaced by 'Uracil (U)'. The DNA code sequence for a complete protein is flanked by stop codons (beginning and end), for example 'TAA'.
The mRNA copies them as front and back cover of the book it wants to read.

After copying, the mRNA leaves the nucleus of the cell as protein code via gates in the core membrane and goes to a protein factory ('ribosome') in a business park around the cell nucleus.
This business park is a labyrinth of membranes ('endoplasmic reticulum').

A ribosome factory (***Fig. 194***) is a large molecule where the mRNA can run through with its codon, so that the intended protein ends up in the right order of amino acids (***Fig. 194*** and ***Fig. 229*** *p243*). The energy needed for that production is gained by converting 'ATP' molecules, the 'batteries' of the cell (***Fig. 195***).
They are recharged elsewhere in a charging factory ('mitochondrium' p219).

CARBON CONNECTS WITH PHOSPHORUS (P)

Phosphorus connects codons in DNA

Fig. 193 showed already phosphorus, oxidized on four sides ('phosphate', PO_4).
In a chain alternating with sugar ('ribose' from ***Fig. 186*** p222), it keeps the amino acids of DNA and RNA together in sequence as a 'backbone'.

a http://aprendendogenetica.blogspot.nl/2011/03/genetica-molecular-aula-3-transcricao.html

Phosphorus is required for energy supply

Phosphorus has also a crucial function in the energy supply. In ***Fig. 195*** the negatively charged AT('tri')P molecule is depicted. If you take off a phosphate group, so that the neutral AD('di')P remains, then that delivers 30kJ/mole of freely available energy.[a]

In ***Fig. 196*** happens something similar when NADPH offers two free hydrogen atoms to oxidize. This enables another molecule to reduce itself (with the energy released).

To see the difference in ***Fig. 195*** and ***Fig. 196***, the H-atoms are also depicted. You also can see that H has one valence, while O, N, C and P have 2, 3, 4 and 5 valences (electron pairs shortage). The dotted and boldly drawn connections only show that they project backwards and forwards in a spatial 3D representation.

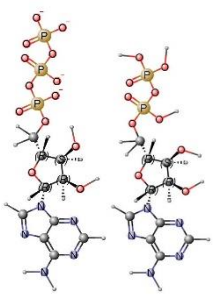


***Fig. 195* ATP→ ADP**

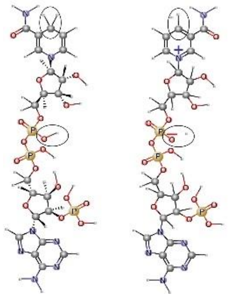


***Fig. 196* NADPH→ NADP**

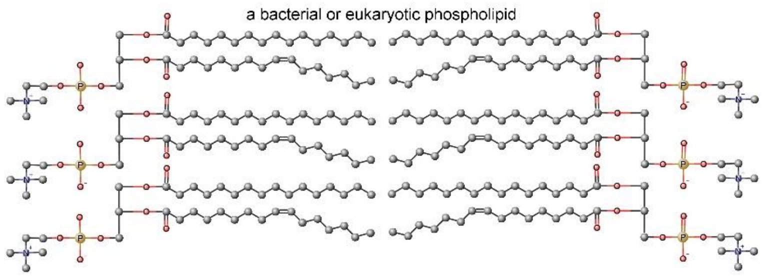


***Fig. 197* A membrane, composed of water-resistant fatty acid tails with a phosphate-containing head that just attracts water, and then turns into surrounding water**

Phosphorus is present in the cell membrane

Fig. 197 shows the role of phosphate in a cell membrane. Membranes are usually composed of molecules ('phospholipids') each with a tail of two long fatty acids (***Fig. 188***, p222). They are again held together by glycerol (***Fig. 185*** p221), but the third branch of the glycerol contains no third fatty acid, but a phosphate-containing head.

The fat tail avoids water ('hydrophobic'), while the head searches for water ('hydrophilic'). In an aqueous environment, phospholipids will automatically turn to the water with the end face to keep the water-avoiding 'fat' sides 'dry' (***Fig. 198***).

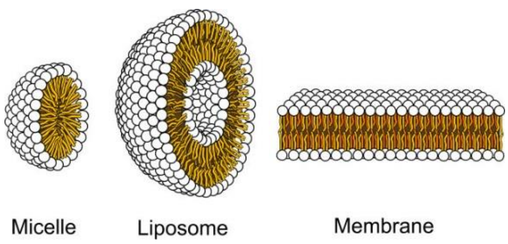


***Fig. 198* Arrangements of polar phospholipids**[b]

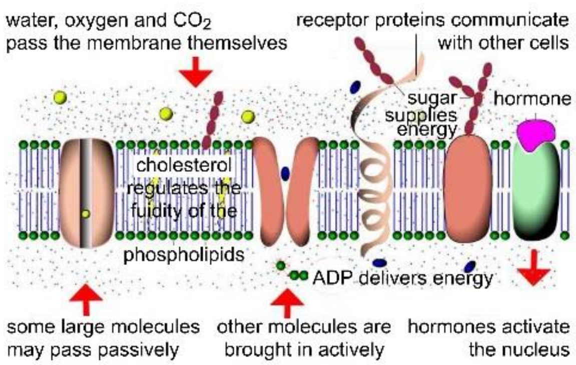


***Fig. 199* Active proteins in the membrane**[c]

a https://en.wikipedia.org/wiki/Adenosine_triphosphate
b Matthias, https://commons.wikimedia.org/wiki/category:liposomes?uselang=fr#/media/File:Phospholipide_in_Wasser.svg
c http://celmodel.jouwweb.nl/bouw-celmembraan

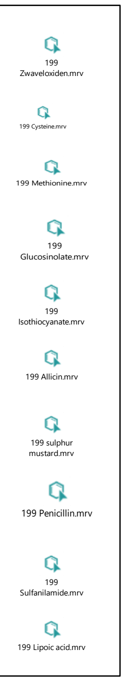
In the simplest case, the phospholipids enclose a sphere with a fatty interior ('micel'). A 'liposome' has a second layer of inversely directed phospholipids separating an aqueous space inside with different reaction conditions than elsewhere in the cell. With such a membrane, any cell is shielded from the unpredictable outside world.

Membranes can contain protein components, devices that selectively regulate transport to both sides, transmit signals, connect itself to a stabilizing structure (an internal 'cytoskeleton' or external 'matrix'), or accelerate reactions on either side of the membrane (hormones and 'enzymes', see further on p231).

CARBON CONNECTS WITH SULFUR (S)

Sulfur dioxide (SO_2) is a well-known industrial pollutant of the atmosphere.
***Fig. 200*A** shows that sulfur (S) in connection with oxygen ('sulfur oxides') can handle different valences (not only 4 like carbon in CO_2).
In water, SO_2 changes into sulfuric acid (H_2SO_4) via the unstable sulfur trioxide (SO_3), resulting in smog and acid rain.[a]

Sulfur trioxide (SO_3, used in smoke bombs) should not be confused with the negatively charged sulphite ion (SO_3^{--}, ***Fig. 200*A.**
This, for example, forms a stable 'salt' with calcium Ca^{++} (the ion connected 'calcium sulphite' $CaSO_3$). Calcium sulphite is to a limited extend allowed as a preservative (E226, for example to prevent fermentation and oxidation of wine).



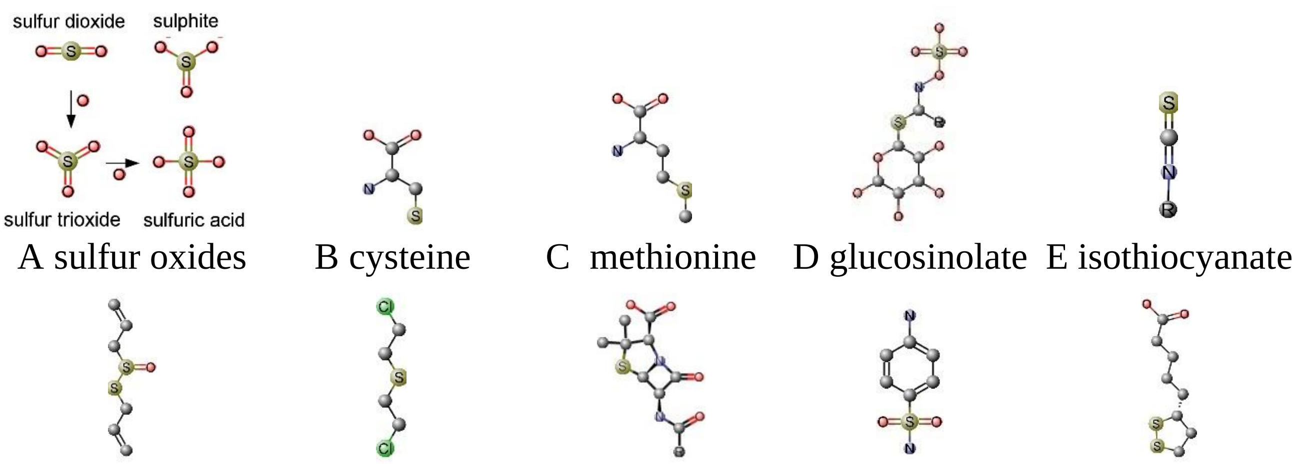


***Fig. 200* Some organic sulfur compounds**[b]

Carbon trioxide must also be distinguished from a negative 'carbonate' ion CO_3^{--}. With calcium^{++} this produces the very stable 'calcium carbonate' ($CaCO_3$), the building block of eggshells, shells, limestone and marble.

---

a CO_2 dissolves through the unstable CO_3 also in water, but especially under pressure. In water it then changes to carbonic acid (H_2CO_4). When we open a bottle of sparkling water, however, we quickly see it disappear as CO_2 in the air.
Sulfur oxide is more prone to water ('hydrophilic') than carbon oxide.

b Zie https://en.wikipedia.org/wiki/Organosulfur_compounds

Sulfur is present in two amino acids
Sulfur has already been recognizable in ***Fig. 192*** on p223 as an element in the amino acids CYS and MET (cysteine and methionine in ***Fig. 200***B and C).
There it appears with a hydrogen atom as -SH (a 'thiol') or as -$CSCH_3$ (a 'thioether') at the end of the tail. It can therefore form a covalent 'sulfur bridge' with another -S or -SC group between or within molecules. As a result, for example, protein clusters remain more solid 'in shape' than with hydrogen bonds alone.

Sulfur is present in skin and hair
The outer layer of our skin ('epidermis') and hair, consist of a strong fiber protein ('keratin', with lots of cysteine and sulfur bridges).
When burning hair you may smell the sulfur. Moreover, the 'vulcanisation' of making rubber is based on the application of sulfur bridges.

Sulfur is present in cabbage and other vegetables
Glucosinolate (***Fig. 200***D) gives characteristic taste to cabbage varieties with different rest groups (R). Eating too much cabbage is not healthy, because glucosinolate is not entirely harmless. Isothiocyanate gives taste to mustard, radish, Brussels sprouts, watercress, East Indian cherry and capers. Allicin does so to garlic (***Fig. 200***E-F**).**

Sulfur smells, and it is used in deadly poison and medicines
The influence of sulfur on olfactory senses is even more apparent when H_2S is released during rotting (rotten egg air). Probably our nose warns with aversion to poisons such as H_2S and SO_2[a] (albeit not against the sulfuric sweetener E950).
Mustard gas (***Fig. 200***G) is extremely toxic. It is a deadly chemical weapon of war.

Penicillin (***Fig. 200***H) with different residual groups (R) kills bacteria by affecting their cell wall. Fortunately, our cell membranes have a different composition, not affected by penicillin. Sulfanilamide (***Fig. 200*** I) is a medicine that kills bacteria, disabling an enzyme that is essential to bacteria, but not for humans.

Sulfur is indispensable in mitochondria
Sulfur is *indispensable* in every organism, and not only in the two mentioned amino acids CYS and MET. Lipoic acid (***Fig. 200***J) helps enzymes (as 'co-factor') in the power plants of all our cells ('mitochondria'). There sulfur also plays a role in a crucial reaction chain that supplies all cells with energy ('citric acid cycle').

Sulfur is present in mucus
It is also an important component in our mucus, a water-rich 'gel' with long chains ('mucin') composed of sulphided amines and sugars ('N-acetylglucosamine' and 'galactose'). The sugar layer is on the outside. It protects the chains from falling out and it attracts water.

Without mucus, our stomach wall would dissolve in the acid.
Our airways would dry out and no unwanted bacteria and viruses would be caught.

a hydrogen sulfide and sulfur dioxide

These are trapped in the mucus and brought to our esophagus with cilia, in order to be made harmless in the acid stomach and intestines.

You may produce more than a liter of beneficial mucus per day for all kinds of functions, and in as many as 20 different types.
Snails and molluscs appreciate that protective fibrous mucus more than we do.

CARBON CONNECTS WITH CHLORINE (CL)

Chlorine (Cl) still lacks one electron in its outer shell and that makes it even more reactive (electro-negative) than oxygen. It tends to supplement the unpaired electron as a radical oxidizer (Cl^-) or to donate it as a reductant (Cl^+).

Chlorine is not present separately as Cl in nature.
Artificially, it can exist as toxic chlorine gas ('dichloro' Cl_2), the chemical weapon that preceded the likewise chlorinated mustard gas in the first world war (***Fig. 200***G).

In a chain it mainly links at the end. There it has often great influence, for example on the force relations in the molecule. It can change the shape of a protein molecule. Chlorine easily connects with virtually every other atom.

Chlorine is a part of gastric acid and table salt

With hydrogen it forms hydrogen chloride (HCl) that disintegrates with water ('dissociates') into H_3O^+ and Cl^- (hydrochloric acid).
Our stomach contains hydrochloric acid, made by gastric wall glands.

After leaving the stomach in the duodenum it is neutralized with sodium hydrogen carbonate ($NaHCO_3$, double carbonic acid soda, baking soda, baking powder or aperient salt[a]) from the pancreas. In this process, it is transformed into kitchen salt (NaCl), the salt of the oceans, our largest stock of chlorine ions.

Chlorine connections are used as solvents and glues

If you replace a hydrogen atom in methane with chlorine, then you get chloromethane (CH_3Cl, 'methyl chloride'). In the past, it has been used as a coolant, but it was highly flammable and toxic. CFCs (Chlorofluorocarbons or 'freon' such as Cl_2CF_2) met the cooling purpose better, but these attack the ozone layer.

Replacing two hydrogen atoms in methane by chlorine, you get a less harmful solvent for hobby glue, a paint stripper or propellant in spray cans (CH_2Cl_2, dichlorocarbon).

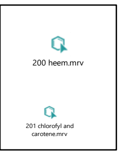
With three chlorines ($CHCl_3$, trichlorocarbon) it becomes the intoxicating chloroform. This is also used as a solvent. In case of four chlorines (CCl_4, carbon tetrachloride) you have the carcinogenic stain water 'tetra'. The name 'tri' is not used for $CHCl_3$, but for C_2HCl_3 ('trichlorethylene') a toxic solvent with two carbon atoms.

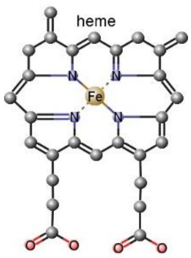
a $NaHCO_3$ also makes water sparkling with carbon dioxide. It is used as baking powder with the carbonic gas to allow dough to rise, or as a aperient salt that helps with heartburn. As a food supplement it is called E500.

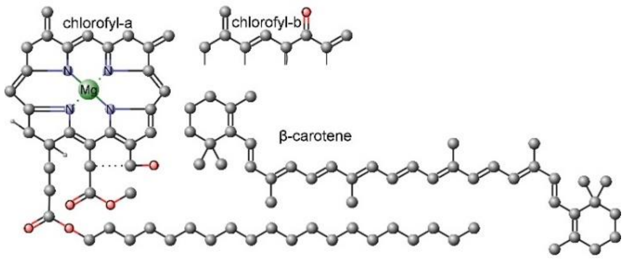
CARBON CONNECTS WITH METALS (CA, MG, K, NA, FE)

Metals enable nerves to function, mainain turgor and are required in enzymes
Ca and Mg are building materials of bones. K^+ and Na^+ ions change the potential of nerve axons, enabeling electron transfer. They also maintain the moisture tension in cells ('turgor'). Zn and Mg are required in different enzymes.

Metals are indispensable in blood and leaf green
Hemoglobin (in red blood cells) consists of four long protein molecules in a globe each with a 'heme' component (***Fig. 201***).
Chlorophyll (leaf green, ***Fig. 201***) looks like heme, but it contains manganese (Mg) instead of iron (Fe).







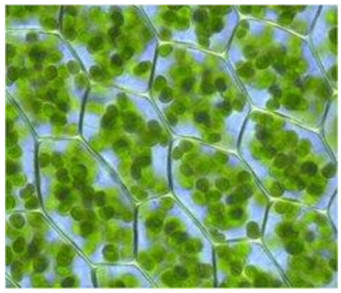


Fig. 201 **Heme** ***Fig. 202 Pigments in leaf green*** ***Fig. 203 Leaf green granules***[a]

Hemoglobine can hold 4 molecules of oxygen (O_2) or carbon dioxide (CO_2) and transport them through the bloodstream.
In order to give you a sense of proportion: every red blood cell contains about 270 million hemoglobin molecules and you have about 25 000 billion red blood cells ...[b]

Chlorophyll and carotene (***Fig. 202***) capture the red and blue light for the energy supply of plants. The green (and/or yellow) light is reflected back unused and that is why we perceive leaves as green.

The collected energy is converted stepwise into sugar in many successive steps. All of these processes occur in the green granules within the cells of leafs (***Fig. 203*** and ***Fig. 204***). With that energy, the plant can build and maintain its organs.

PHOTOSYNTHESIS CAPTURES ENERGY FROM LIGHT

The leaves of plants are made up of cells with leaf green granules ('chloroplasts'). These are cells in cells (liposomes) with a double membrane (see ***Fig. 198*** p225). In turn, a chloroplast in its membrane houses hundreds of even smaller disc-shaped liposomes ('thylakiods', see ***Fig. 204***).

a Foto Kristian Peters leaf chloroplasts of many-fruited thyme-moss (Plagiomnium affine) http://www.dse.nl/~dekempvis/planten/algen.html
b https://nl.wikipedia.org/wiki/Rode_bloedcel

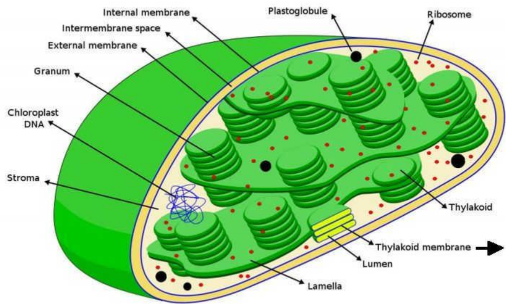


Fig. 204 A **leaf green granule**[a]

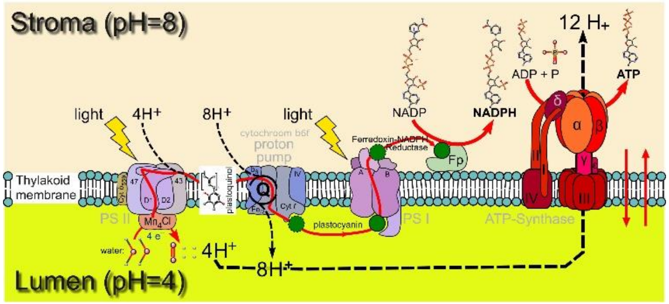


Fig. 205 The thylakiod-membrane[b]

The interior ('lumen') of these thylakiods is less acidic (pH=4) than the 'stroma' outside (pH=8). The double membrane of the basic chloroplast protects against the slightly acid environment of the cell as a whole ('cytoplasm', approximately pH=5).

A leaf green granule contains 5 types of devices

The thylakoid membrane (separating the lumen from the stroma outside) contains everywhere 5 different protein systems.
These systems store energy from the sun, pump products from the stroma inwards to keep the lumen less acidic, produce something themselves, or load used ADP and NADP to ATP and NADPH (***Fig. 195*** and ***Fig. 196*** p225).

The first and third system contain chlorophyll.
They can capture light energy and store that energy in connections for the other systems, providing energy for other products and services without light (***Fig. 205***).
The end product of this factory with five machines is charged ATP and NADPH.

With ATP every cell of all living organisms is chemically supplied by small packages of energy (by oxidising it to ADP, see ***Fig. 195*** p225), but all cells also have their own charging factory (mitochondrium p219). It does not run on light.It burns carbon with O_2 into CO_2, respectively supplied and drained by the blood.
NADPH is needed elsewhere in the chloroplast as an energy supply (by extracting two H hydrogen atoms, leaving NADP to be recharged, ***Fig. 196*** p225).

The first machine in ***Fig. 205*** is called 'PS II' because the third party ('PS I') has been discovered first. With the light energy from its chlorophyll, that first system PS II makes an energy-rich connection ('plastoquinol') with which the second system can do its work without light energy.

PS II also splits water ($2H_2O$) in oxygen (O_2) and protons ($4H^+$) on the inside of the membrane to keep the lumen less acidic (pH = 4).
It takes a lot of energy to collect the hungry oxygen from his H prey. The oxygen is discharged to the outside air, so that animals can also live (by re-oxidizing C with O_2).

This deacidification of the lumen is completed by the second machine ('Cytochrome b6f') which is also known as 'proton pump' (***Fig. 205***Q).

a http://celmodel.jouwweb.nl/chloroplasten
b Adaptation of a figure from https://nl.wikipedia.org/wiki/Lichtreacties

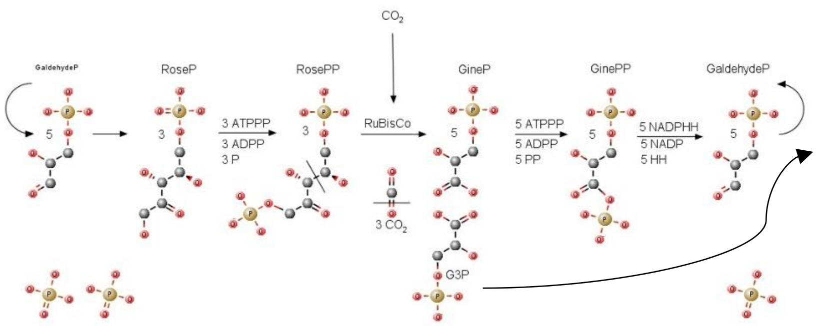
With the energy of the plastoquinol from PS II, it pumps against the current another twice as many protons ($8H^+$) from the stroma into the already less acidic luma inside. There is enough plastoquinol energy left, to make a large protein molecule ('plastocyanin'), with which the third machine can do its work.

With that protein molecule the third machine ('PS I') again uses light to make a different product ('Ferredoxin-NADPH Reductase' or 'FNR').
With FNR, the fourth machine will recharge NADP to NADPH on the outside.

Finally, the fifth machine ('ATP synthase') loads the finished ADP (also on the outside) up to ATP, so that enough energy is available in the stroma. The energy for that charging itself is obtained by letting the protons (H^+) flow back to the stroma (from where they have been brought with so much effort upstream into the lumen). This machine is also used in the charging factory ('mitochondrium') of any cell.[a]

The Calvin cycle makes sugar and starch splitting CO_2
In the stroma of a chloroplast (the green granule in leafs), the charged compounds ATP and NADPH from the thylakiodes offer the energy for the great achievement of green plants: splitting the CO_2 we produce as animals, now causing climate change.

In the 'Calvin cycle' (***Fig. 206***) the carbon dioxide gas CO_2 from the air, is split into C and O with the crucial enzyme 'RuBisCo'. This makes from three large molecules (RosePP) six small ones (G3P)[b]. Five G3P molecules are re-used in the cycle before one is available for the production of sugar and starch elsewhere (***Fig. 207***).



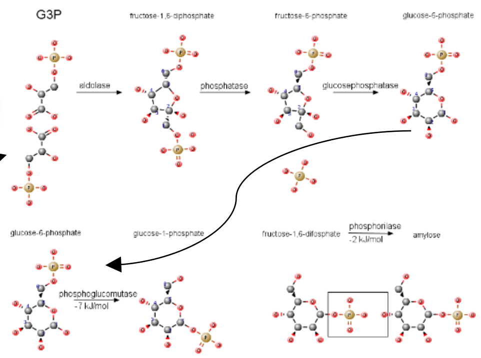


Fig. 206 De Calvin cycle makes 'G3P'… ***Fig. 207 ... of which starch is made***[c]

From the produced 'G3P' (glyceraldehyde-3-phosphate), phosphates of fructose and glucose are made (***Fig. 207***[d]), and finally 'amylose', a crucial component of starch. Together with the similar 'amylopectin' (see also ***Fig. 187***), this 'starch' is the energy supply in each plant and it is the largest share in our food.

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a http://www.atpsynthase.info/
b These are no official names and only used here to keep an overview in the drawing.
c Above all the arrows representing the reaction, the names of the enzymes involved have now been put and below that also in the bottom row the energy in kJ/mol that is released. That is a negative number with minus sign, because it is extracted from the bound sugar molecules ('exotherm'). The reaction thus runs, once activated, largely automatically. There is no need for energy ('endotherm') as in ***Fig. 206***, where, among other things, the C is released from CO_2.
d In ***Fig. 207*** in addition to the required and released water and hydrogen atoms, the ATP → ADP reactions that provide the energy are also omitted, but the usual names have been used again. Such names now contain the figures that indicate the position of the phosphate groups in the carbon chain.

Enzymes accelerate chemical processes

Such reactions hardly take place outside a living cell and without enzymes.

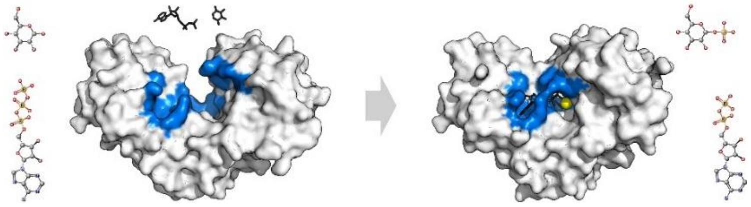

Fig. 208 An enzyme attaches a phosphate group to a sugar molecule[a]

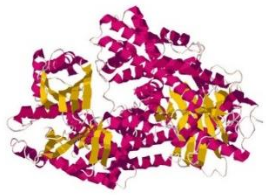

Fig. 209 **…its 'enzyme structure'**[b]

With all the necessary ingredients dissolved in a glass of water you can wait a long time for the target molecule emerges somewhere. If you, however, add a specific protein ('enzyme') from the living cell, then it can go a billion times faster.
You have to ensure the correct temperature and acidity (pH), otherwise the enzyme will not work. For each reaction you need a specific enzyme.

The internet contains impressive catalogs of those tens of thousands of enzymes that keep our live going. In ***Fig. 208*** the enzyme 'hexokinase' extracts a phosphate from an ATP battery and adds it to grape sugar (glucose).

With this, grape sugar can again polymerize into starch.
This requires another enzyme ('phosphorilase', see ***Fig. 207***).
Names of enzymes usually end on '-ase', as a sugar ends with '-ose', an alcohol on '-ol, an aldehyde on -al and so on (***Fig***. 184 p221 and subsequent figures).

In ***Fig. 208*** you can see that the enzyme grasps the two output components ('substrates'), and closes itself around the substrate as a pair of pliers. Thereby its shape changes, and it even places a bridge over it to hold it. Once the components are connected, the enzyme will release the new 'glucose-1-phosphate', ready for the next substrate pair. This happens incredibly fast and the enzyme remains unchanged itself. You need only a little of enzyme to 'phosphatize' a whole glass of sugar water with phosphate in the blink of an eye.

Enzymes build, break down or transform molecules

In ***Fig. 206*** and ***Fig. 207*** on p231 molecules are not only broken down and built up, but also transformed.

For example, the enzyme 'glucophosphatase' changes the pentagonal fructose ring into the hexagonal glucose ring with the same chemical formula ($C_6H_{13}O_9P$), but it becomes a different compound. In such a case one speaks of 'isomers'. Enzymes that make a compound into a different isomer are summarized in the name 'isomerases'.

a Thomas Shafee https://en.wikipedia.org/wiki/User:Evolution_and_evolvability.
b Hexokinase according to https://commons.wikimedia.org/wiki/File:Hexokinase_3O08.png

The following enzyme of ***Fig. 207*** ('phosphoglucomutase') is also such an isomerase. It moves the phosphate group only from carbon atom 1 to carbon atom 6, so that the compound changes from glucose-1-phosphate to glucose-6-phosphate.

Attaching to carbon atom 6 apparently provides more energy (-7 kJ / mol) than what has been taken for the release of phosphate to carbon atom number 1.[a]
Proteins must be built first before you can break them down. We know more about decomposition by enzymes than about how proteins are actually being constructed.

Plants construct the carbohydrates and proteins that animals digest and break down. Our digestion system consists almost entirely of the difficult breakdown of complex sugars, fats and proteins into simple sugars ('mono-saccharides'), fatty acids and amino acids, which are rebuilt into usable substances outside the intestines.

It's not easy to break down a molecule carefully into specifically usable components. Each substrate usually fits only to one enzyme as a key in its own specific lock.
For example, the enzyme 'lactase' specifically accepts only lactose and 'cellulase' only polymeric cellulose in order to make useful glucose (***Fig. 210-Fig. 213***).

Cellulose (see ***Fig. 186*** on p222 and ***Fig. 213*** below) is a sugar in polymeric fibers, an essential substance in plant cell walls. It is important in our diet as a source of fibre, but we cannot digest it. Ruminants have an extra stomach ('rumen') with enzymes such as cellulase or enzyme-carrying bacteria, which can do so indeed.[b]

Fig. 210 Lactose

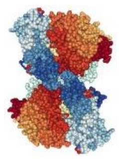

Fig. 211 Lactase[c]

Fig. 212 Cellulose

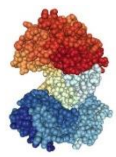

Fig. 213 Cellulase[d]

There are, however, deceptive substrates.
Such a 'pseudo-substrate' then fits in the enzyme, but it cannot be released anymore. 'Poison' is often blocking an enzyme by a pseudo-substrate.

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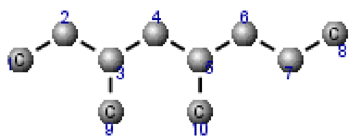
a Number the carbons of the longest C chain from the side that gives C-branches their smallest number. For example 3,5-dimethyloctane:



see further http://www.chem.uiuc.edu/GenChemReferences/nomenclature_rules.html

b Our DNA does not contain an order of amino acids for cellulase, but (in case you want to eat grass) here is the amino acid sequence of the cellulase of ***Fig. 213*** (in the one character code of ***Fig. 192***):
MDEGAKQTDIQSYVADMQPGWNLGNTFDAVGDDETAWGNPRVTRELIKTIADEGYKSIRIPVTWENQMGNAPDYTINEDFFSRVEQVIDWALEEDLYVMLNLHHDSWLWIYNMEHNYDEVMAKYTALWEQLSERFQGHSHK
LMFESVNEPRFTRDWGEIQENHHAFLEELNTAFYHIVRESGGSNTERPLVLPTLETATSQDLLNRLHQTMKDLNDPNLIATVHYYGFWPFSVNVAGYTRFEEETQQDIIDTFNRVHNTFTANGIPVVLGEFGLLGFDTSTDVIQQGE
KLKFFEFLIHHLNERDVTHMLWDNGQHLNRETYSWYDQEFHNMLKASWEGRSATAESNLIHVRDGEPIRDQDIQLHLHGNELTGLQVDGDSLALGEDYELAGDVLTMKADALTALMTPGELGTNAVITAQFNSGADWHFQLQ
NVDEPTLENTEGSTSNFAIPAHFNGDSVATMEAVYANGEFAGPQNWTSFKEFGYTFSPVYDKGEIVITDAFFNEVRDDDIHLTFHFWSGEMVEYTLSKNGNHVQGRR
If it does not work, then there are many other types of cellulase, see http://www.rcsb.org/pdb/files/fasta.txt?structureIdList=5E09

c http://www.rcsb.org/pdb/ngl/ngl.do?pdbid=3WEZ&bionumber=1
Rose;Bradley;Valasatava;Duarte;Prlić;Rose(2016)Web-based molecular graphics for large complexes(ACM Proceedings of the 21st International Conference on Web3D Technology)Web3D '16: 185-186, 2016. doi:10.1145/2945292.2945324 AS
Rose;Hildebrand(2015)NGL Viewer: a web application for molecular visualization. Nucl Acids Res (WWW) 43 W1: W576-W579 1 July 2015 first published online April 29, 2015. doi:10.1093/nar/gkv402

d http://www.rcsb.org/pdb/ngl/ngl.do?pdbid=5E09 idem

On the other hand, many medications have been made to restore or even slow down enzyme actions in our body.

§ 39 METABOLISM, REPRODUCTION AND ENCLOSURE ENABLE LIFE

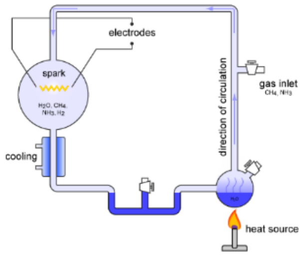
THE ORIGINAL ABIOTIC ENVIRONMENT GENERATED LITTLE ORGANIC COMPONENTS

The original atmosphere enabled little

It has been assumed earlier, that the first phenomena of life emerged some 4 billion years ago in hot liquid water (H_2O) under a stormy, lightning atmosphere, mainly consisting of methane (CH_4), ammonia (NH_3) and hydrogen (H_2).

There was virtually no oxygen (O_2) and therefore no ozone layer (O_3) that could stop ultraviolet radiation. So, rocks and minerals were hardly oxidized.
Such an atmosphere also exists on other planets, but then the water is mainly present as ice or gas due to their smaller or greater distance to the sun.

This atmosphere was simulated in 1952 in a sterile closed circuit with only pure water, methane, ammonia and hydrogen (***Fig. 214***).[a]



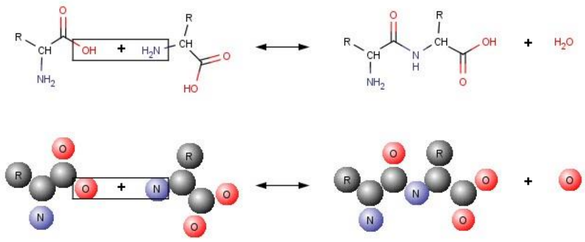


Fig. 214 Miller-Urey- experiment[b] ***Fig. 215 Two amino acids join to peptide and vice versa***

Thanks to built-in electric discharges, a large number of different organic substances, such as amino acids, arose in that circuit. With targeted supply of energy, these amino acids could join together as building blocks in chains to all proteins necessary for life.

There are, however, about 500 different amino acids (depending on what you enter for 'R' in ***Fig. 215***). Of these, only 20 are applied in a living organism.
From 20 amino acids you can combine $20^2 = 400$ different peptides, but if 1000 amino acids in a protein should have a strict sequence, then there are 20^{1000} proteins possible.

If it is improbable that a protein chain will arise of itself without immediately falling apart again[c], then it is even more unlikely that the required sequence can also be applied in any living organism.

After 1952, different theories have emerged on the original environment as the first condition for developing life from dead matter ('abiogenesis').
It has been assumed that the atmosphere on earth about 4000 million years ago consisted of water vapor (H_2O), nitrogen (NH_3) and carbon dioxide (CO_2), with smaller amounts of carbon monoxide (CO) and sulfur compounds.

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a Miller(1953)A Production of Amino Acids under Possible Primitive Earth Conditions STOR(Science)0515 117 3046 p528
b https://en.wikipedia.org/wiki/Miller–Urey_experiment
c In the absence of oxidizing oxygen in the original atmosphere, that would be better. Bok (1963) Het ontstaan van het leven (Utrecht) Spectrum Aula, also assumes connection more likely than separating (the arrow to the left in **Fig. 215**). Separation usually costs more energy.

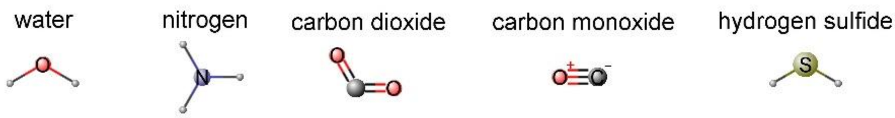
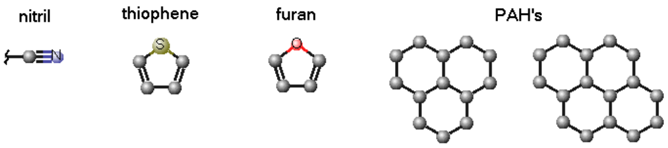


Fig. 216 Assumed global composition of the original atmosphere

Free hydrogen and noble gas molecules largely disappeared into the surrounding space because they could not be retained by gravity due to their low mass at these high temperatures (motility).

Vulcanos under water enable a little more
On the seabed, the still thin, cracked earth crust, was broken through by volcanoes. Emissions from the current volcanoes gives an impression of materials that were still available at the surface.



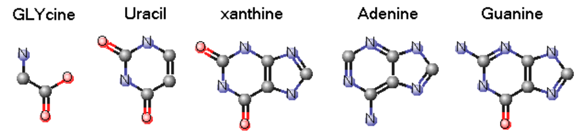


Fig. 217 Components found in volcanic emissions *Fig. 218 Components found in meteorites*

"More than 200 compounds have been detected, such as alkanes, alkenes, arenes such as benzol (***Fig.*** 184 p221), phenols, aldehydes, esters, ketones (***Fig. 185*** p221), carboxylic acids (***Fig. 188*** p222), nitriles, and variants of PAHs (***Fig. 217)*** with other components: chloro-, methyl- and sulfur, and pentagonal thiophenes and furans.".[a]

The air pollution surpassed the current industrial pollution many orders of magnitude. The atmosphere was one large chemical laboratory that continued in the sea.

Meteorites may have delivered a protein, some RNA bases and phosphor
Carbon is the most common element in the universe after hydrogen, helium and oxygen. It appears for 20% in the form of PAHs (***Fig. 217***). These have also been found in the universe in many variants. Ionizing radiation around stars in conditions that do not occur on earth can form complex connections there, and the earth has received many meteors[b], meteorites and comets in its life time.

They caused high temperatures locally, as well as volcanoes, receiving and producing complex compounds. In meteorites (***Fig. 218***), among others, the protein glycine (GLY in ***Fig. 192*** p223 and the two preceding figures) and the RNA bases ('nucleo-bases') Uracil, Guanine[c] and Adenine were found (U, G and A in ***Fig. 193*** p224).

Glycoaldehyde (***Fig. 219***) has also been spotted in the center of the Milky Way. It can produce sugars ('formose reactions'). Computer models simulate also the creation of connections in gas clouds around the sun.

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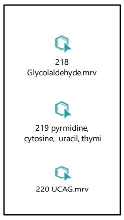
a Free according to Schwandner(2013)Halocarbons and other trace heteroatomic organic compounds in volcanic gases from Vulcano(Geochimica et Cosmochimica Acra) 101 191-221. www.elsevier.com/locate/gca

b Meteors could have a diameter of 500km. Such an enormous impact may have caused the separation of the Moon. It gave so much heat that the ocean evaporated, and clouds to great heights enveloped the whole earth in darkness. Only after 3000 years would rains have filled the ocean again.

c https://en.wikipedia.org/wiki/Murchison_meteorite



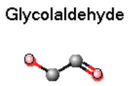


***Fig. 219* Found in the Milky Way**

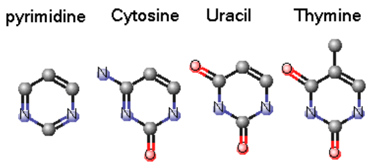


Fig. 220 Predicted by computer model in gas clouds around the sun

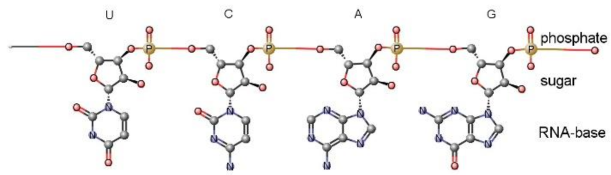


Fig. 221 The four RNA bases UCAG (Uracil, Cytosine, Adenine and Guanine) as a part of an RNA chain

Some compounds are difficult to detect, but according to these models the other two RNA bases Cytosine and Thymine (C and T in ***Fig. 193*** p224) must have been present (***Fig. 220***, Thymine behaves in the DNA as Uracil in the RNA).
With this, all four RNA bases U, C, A and G can be composed (***Fig. 221***).

Phosphor plays a crucial role

The RNA bases are sequenced by a backbone of sugar and phosphate.
The sugar pentagon may be composed of Glycoaldehyde ('formose reactions').
What remains as an issue is the origin of phosphate.

There are artificial chains without phosphate designed and realized that could keep RNA bases in order. It is then questionable whether there were circumstances of 4.5 billion years ago, in which the ingredients, pressure, and temperature (more than 100°C in water) were concentrated (deep sea volcanoes) in which they could originate and subsequently make the enzyme that could have made the phosphate-carbon bond.

Phosphate plays a crucial role not only in RNA and DNA.
The energy supply for virtually all organic reactions (***Fig. 195*** and ***Fig. 196*** p225), the formation of cell membranes (***Fig. 197*** p225), the stabilization of the acidity in a cell, the formation of bones and teeth, etc., all require phosphate.

A sufficient agricultural production for our exponentially increasing human world population depends on the availability of artificial fertilizer. Phosphate is a limiting component. It is extracted as fluorapatite and hydroxyapatite ($Ca_5(PO_4)_3F$ and $Ca_5(PO_4)_3OH$, ***Fig. 222***)[a] from the finite stock that is still stored in a few mines.

The origin of these rare concentrations is difficult to understand without enzymes, given the insolubility of other phosphate. This precious resource, through agriculture dispersed in the oceans, cannot be recovered. When that stock is exhausted, there will be a global food shortage in which only the 3 billion of the richest will survive.

Phosphate is present in the earth's crust in many compounds (especially with metals) and it is found in meteorites, but not in a form that is accessible by living organisms. Most forms are solid at normal pressure, temperature and acidity and practically insoluble in water. It is not clear yet which chemical path and under what conditions these phosphates could also form organic carbon compounds.

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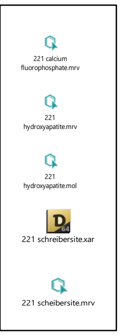
a https://en.wikipedia.org/wiki/Fertilizer#Phosphate_fertilizers https://en.wikipedia.org/wiki/Phosphate

Phosphor is rarely accessible to life

In the prebiotic environment, complex enzymes were not yet available to create such improbable phosphor connections. In meteors, however, a rare phosphate mineral has been found ('schreiber site', ***Fig. 222***), which has access to living matter via a conceivable chemical path. There was a meteor shower in the early days of life that brought enough schreibersite on earth to make that path plausible at the time.[a]



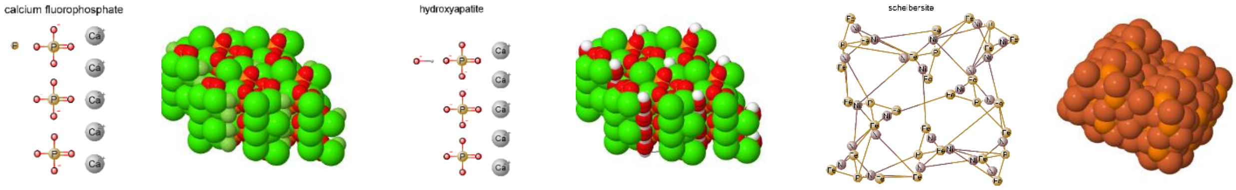


Fig. 222 **Available phosphate-containing minerals**[b]

You may therefore assume that the building blocks for RNA, but also for the amino acids (***Fig. 192*** p223), proteins and enzymes, were already present in the earth's crust, in the sea or in the atmosphere at the origin of life.
The conditions for developing their more complex compounds varied on Earth in sufficient space and time for locally rare chemical reactions.

In the first place, there were large differences in temperature and pressure that allowed local and temporary improbable reactions.
Furthermore, numerous interfaces and cavities were available. These offered gradual transitions (gradients), an accessible medium (water) and protected environments in which complex compounds could survive.

METABOLISM CHANGES CHEMICAL CONNECTIONS

Metabolism is a succession of chemical reactions changing selected substances.
In this section 'metabolism' refers in particular to the conversion of abiotic materials into the organic compounds of living organisms.

Gradients around seabed vulcanos produce a variety of connections

A submarine volcano supplies (in a water-rich environment under pressure) various building materials that partly settle on the bottom, where they can form vertical gradient. (***Fig. 223***).

A *horizontal* gradient of descending temperature and chemical composition emerges around the volcano. These vertical and horizontal gradients provide an endless number of reaction conditions that can produce organic compounds ('metabolism').

The liquid magma[c] in the volcano itself cools off. A cooling white or black plume of smoke rises. Here, the widely varying and fluctuating temperature differences can provide the energy for unlikely organic compounds that can escape to the colder environment and stabilize ('thermosynthesis')[d].

a Pasek(2017)Schreibersite on the early Earth Scenarios for prebiotic phosphorylation(Geoscience Frontiers) 8 329-335
b https://www.mineralienatlas.de
c https://nl.wikipedia.org/wiki/Magma_(gesteente)
d https://en.wikipedia.org/wiki/Thermosynthesis

The first mineral that crystallizes (already at 1200°C) in the cooling magma is **olivine** (***Fig. 224***). Such mineral weathers on exposure to CO_2 and water ('serpentinization'[a]). It therefore occurs less on the earth's surface than in magma and in the earth's crust.

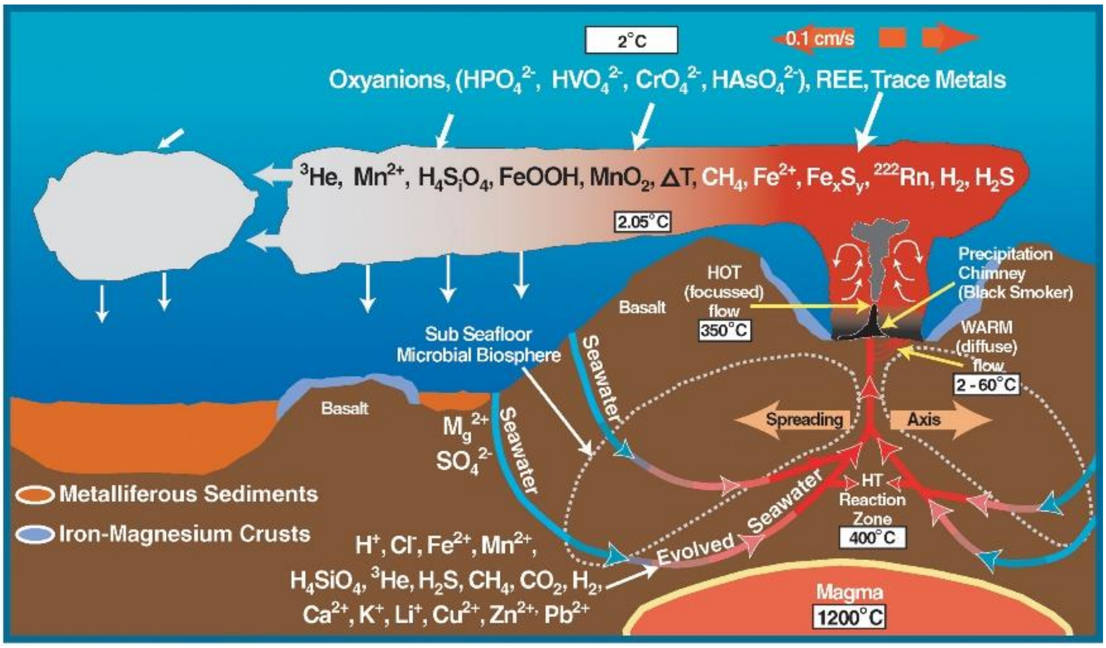
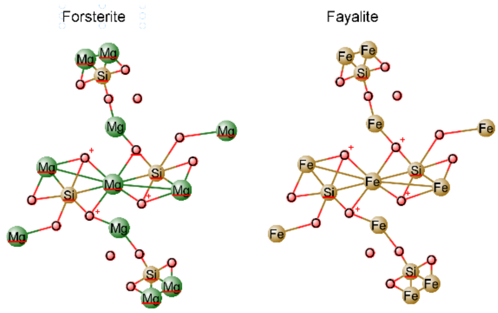


Fig. 223 **Seabed volcano**[b]



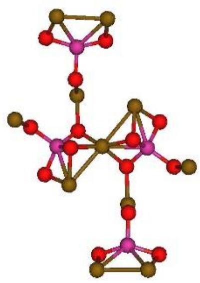


Fig. 224 Olivine[c] ***Fig. 225 Components of olivine*** ***Fig. 226 Fayalit 3D***

The components of olivine are forsterite (Mg_2SiO_4) and fayalite (Fe_2SiO_4).
The magnesium-containing component of olivine ('forsterite', ***Fig. 225***) binds CO_2 and decays into harmless and stable limestone or dolomite. This CO_2-binding capacity of olivine is seen as an opportunity to combat climate change.[d]

Not light, but hydrogen may have been the first energy supply of life
The iron-containing component of olivine ('fayalite', ***Fig. 226***) falls apart with water in an iron oxide ('magnetite'), gravel and loose hydrogen molecules.

a https://en.wikipedia.org/wiki/Serpentinite
b https://en.wikipedia.org/wiki/Hydrothermal_vent
c https://nl.wikipedia.org/wiki/Olivijn
d A liter of olivine ('green sand') as soil cover or natural fertilizer compensates for the CO_2 emissions of about 1 liter of petrol.http://www.innovationconcepts.eu/res/literatuurSchuiling/olivineagainstclimatechange23.pdf http://www.greensand.nl/

This spontaneous reaction makes free hydrogen locally and temporally available before it is leaving into space due to its volatily.
That has been observed also in current deep-sea volcanoes.[a]

It is conceivable that from the origin of the earth this process provided the chemical energy packages (***Fig. 195*** p225) that were necessary for reactions in the first life phenomena in steps *per molecule*. Free hydrogen can reduce *carbon dioxide* to methane with energy gains ($CO_2 + 4H_2 \dashrightarrow CH_4 + 2H_2O$).

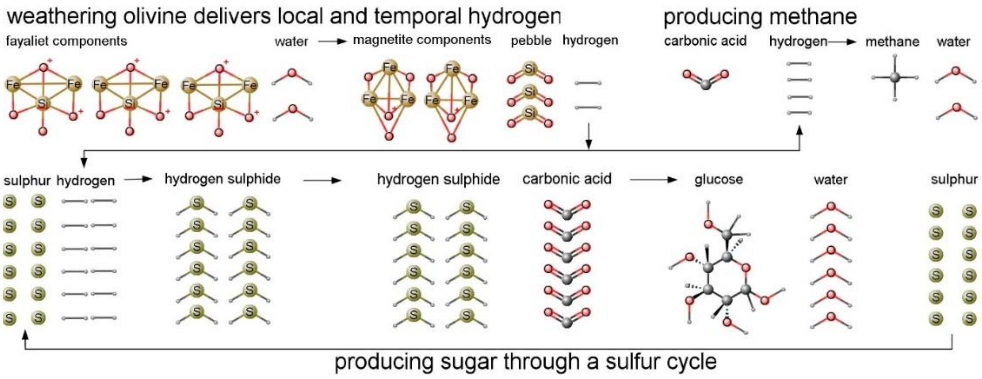


Fig. 227 Hydrogen from olivine (fayalite), used to make methane and sugar in a sulfur cycle

There are still primitive single-celled organisms ('archaea' types) that use methane as the only source of energy and carbon ('methanotrophs') without oxygen ('anaerobic').[b]

Free hydrogen can also bind to sulfur (S) with energy gains ($S+H_2 \dashrightarrow H_2S$).
This results in the hydrogen sulphide (H_2S), smelling of rotten eggs.

With hydrogen sulphide, CO_2 is converted into glucose, $C_6H_{12}O_6$ to this day by 'purple sulfur bacteria' ('chemosynthesis': $12H_2S + 6CO_2 \rightarrow C_6H_{12}O_6 + 6H_2O + 12S$), leaving pure sulfur (S) in small granules available for another cycle.

In this cycle, hydrogen (H_2) is the volatile energy carrier and sulfur (S) is the facilitator that provides access to more complex organic compounds.

Before oxygen could play a role as an oxidator (electron acceptor), micro-organisms 'breathed' sulfur. The 'sulfur cycle' has naturally become much more complicated over time and now plays a crucial role in many life processes.[c]

Microbial mats may have been the early intestines of life

The oldest known fossil survivors are 'microbial mats' (***Fig. 228***), layered structures of a few millimeters thick. Their vertical gradient (gradual transition) of stacked (from bottom to top increasingly complex) life forms, ends with silicic bacteria that protect against the aggressive outside world.

a Proskurowski(2008)Abiogenic Hydrocarbon Production at Lost City Hydrothermal Field(Science)0201 319 p604 http://science.sciencemag.org/content/319/5863/604.full
b https://en.wikipedia.org/wiki/Methanotroph ; Wang(2014)Methanotrophic archaea(The ISME Journal)8 1069–1078
c https://en.wikipedia.org/wiki/Sulfur_cycle

They appear in shallow seas, on flooded banks[a] and even on dry land. The different kinds survive temperatures from -40 to 120ºC. The ecosystem of vertically successive series resembles the transition from our intestinal flora to organism.
Our 'intestinal wall' is a selective barrier, but the microbial mat is a gradient.

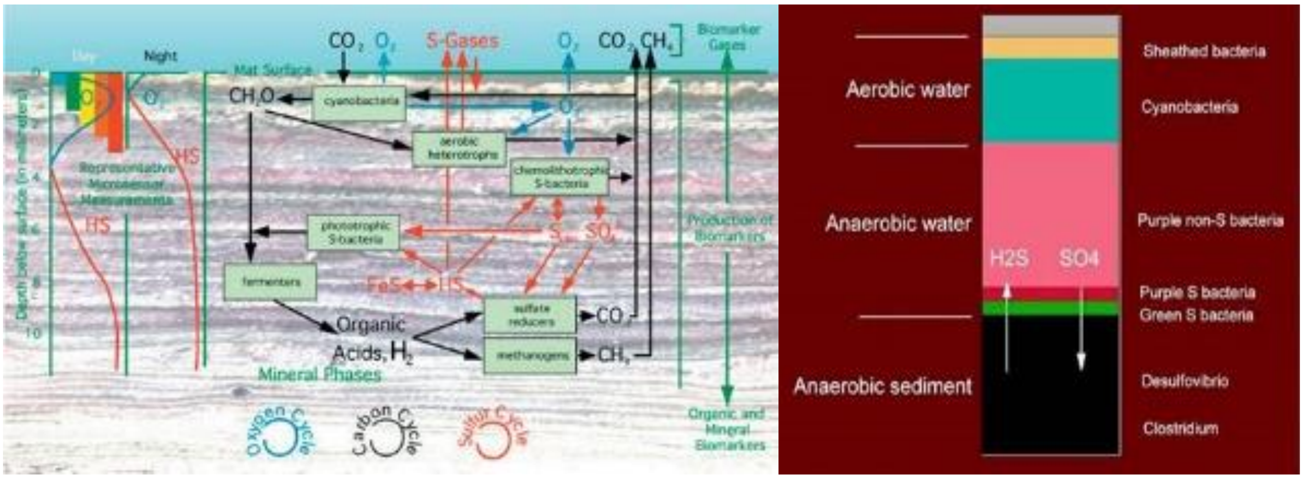


Fig. 228 Microbial mat[b]

In developed organisms all incoming nutrients are first broken down in a digestive tract into elementary abiotic amino acids, sugars and required minerals, more or less in the same form as they should have been present at the beginning of life.

Via a selective intestinal wall they are delivered to the organism. Intestines may be counted as external to the rest of the organism. There, the *construction* starts: energy supplies from elementary sugars, proteins from amino acids and enzymes from proteins, supplemented with specific minerals.

In the intestines the selection and *degradation* takes place by acid, alkaline lye, and a complex ecosystem (an 'intestinal flora' that can be different in every individual), composed of many microorganisms that have their own degrading enzymes.
These enzymes are not present in the organism itself and often harmful within it.

That breakdown costs (counter-intuitive) dissolution energy, while building up liberates binding energy (***Fig. 183*** p219).
The composition of complex proteins in the correct order of amino acids requires construction and degradation within the organism.

Providing and disposing energy at the right place and time must be done in a controlled manner (done by enzymes) and should not be disturbed by non-directed energies and aggressions from outside.

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a Fluctuations in wetting and drying up, freezing and melting can yield the necessary concentrations. Dehydration can bind amino acids to chains and form bridges. Cooking precipitates solutes or denatures macromolecules (for example, cooking eggs). Freezing crystallizes first the pure water and concentrates the 'contaminating' other compounds in cavities.
b http://teachersinstitute.yale.edu/curriculum/units/2010/3/10.03.04.x.html

REPRODUCTION REQUIRES MODIFIED REPETITION

Reproduction supposes *repetition*, be it not always exact repetition.
Before a fully grown multicellular organism can propagate as a whole, its *cells* must have repeatedly multiplied by division ('mitosis').
This supposes that individual cells have been separated from the outside world at all.

This happens mainly by a cell membrane (***Fig. 197*** p225 and ***Fig. 198*** p225).
At their turn surrounded by a skin, reproduced cells can develop into different organs ('cell differentiation').

Within the cells, reactions take place that have to *repeat* themselves endlessly in order to have the right raw materials available in the right quantities for all life processes.
This repetition usually occurs in a closed circle of consecutive reactions, a 'cycle' such as the sulfur cycle described above (***Fig. 227***).

Such a cycle is kept going by an external energy source that also permanently (*repeating*) should deliver its product such as weathering olivine.

Reproduction of large molecules requires a memory

With two atoms their order in the molecule is not important. The repeated formation of large complex molecules, however, such as proteins from amino acids in a strict order (***Fig. 192*** p223), requires a memory[a] to remember the order in which hundreds of amino acids must often be installed producing the protein that corresponds to its function (as a building material or an advanced production unit).

In all now living organisms that memory is located in DNA.
Its components have been extensively investigated.[b] An organism, containing only the genes that are now the same in every living being, has been reconstructed as 'the Last Universal Common Ancestor' ('LUCA'). LUCA should have lived in hot water, in an anaerobic, chemically active environment with H_2, CO_2 and iron.[c]

Fig. 229-Fig. 231 show in more detail than ***Fig. 194*** on p224 how RNA copies of DNA are applied to construct proteins from free amino acids.
It *repeats* itself endlessly throughout your body as a prototype of reproduction in living beings and in all forms of reproduction that subsequently have been developed.

Each of the 20 amino acids has its own means of transport: a transfer RNA ('tRNA') with a three-character code ('anticodon') of that amino acid (***Fig. 193*** p224).

That specific tRNA searches in the cell 'its' amino acid and takes it to a protein factory ('ribosome' p224). As soon as the relevant code passes, it attaches itself with its amino acid baggage to deliver it for protein construction.
After delivery, it will 'search' in the cell for a new specimen of its amino acid again.

---

a Schrodinger(1948)What is life(Cambridge)University Press
b Wade(2016)Meet Luca, the Ancestor of All Living Things(The New York Times)0725 https://www.nytimes.com/2016/07/26/science/last-universal-ancestor.html). Weiss(2016)The physiology and habitat of the last universal common ancestor(Nature Microbiology)1 16116. PMID 27562259 https://www.ncbi.nlm.nih.gov/pubmed/27562259)
c https://en.wikipedia.org/wiki/RNA_world

229 Klaverblad.mrv
230 Codon-Anticodon.mrv

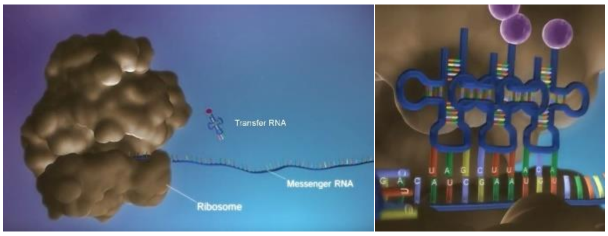

Fig. 229 Protein production in a ribsome[a]

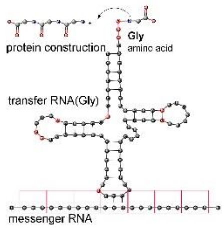

Fig. 230 mRNA and tRNA[b]

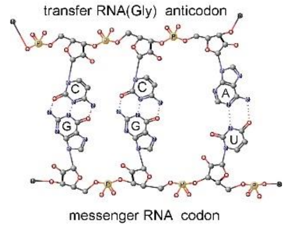

Fig. 231 Codon and anticodon

This happens about 60 times per second.[c] A protein of 600 amino acids is thus made in 10 seconds. The process ends when the ribosome reads a stop sign in mRNA.
The complete protein chain is then released and folds up with cross-connections to the unique stable form for that protein in which it can function.

The RNA books preceded the DNA library
According to the now dominant view, life began with the reproduction of proteins by RNA chains in an 'RNA world'. Only then would a DNA library with double chains (as a risk coverage) be created in each cell. After all, there are still pathogens ('viroids') that simply consist of loose circular RNA chains ('plastids'), although they can only now reproduce in a host with ribosomes and suitable protein enzymes.[d]

Perhaps a form of reproduction is conceivable, in which such loose RNA chains bind sequences of codons with anti-codons. They function the same as negative to form positive RNAs again. The question then is, how these positives and negatives come to a backbone that keep them together as a chain.

The backbone of RNA consists of phosphate and sugar (***Fig. 231***), but there are simpler alternatives.[e]

Without intervening RNA, amino acids can also link up to peptides at more than 140ºC. When they dry out of a solution, they become longer polymers, proteins.
With phosphoric acid as a catalyst, protein-like structures ('proteinoids') with cross-links are formed at 70°C, in which 18 of the known 20 amino acids have been found.[f]

In water, some of them are unilaterally water-averse (hydrophobic).
They then make (in the same way as the phospholipids in ***Fig. 198*** p225) spherical 'proteinoid microspheres' also found in volcanoes.
They, however, do not yet have the correct sequence to form a functioning protein.

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a https://www.youtube.com/watch?v=gG7uCskUOrA gives an impression of this reproduction. More details are shown in https://www.youtube.com/watch?v=kmrUzDYAmEI en https://www.youtube.com/watch?v=8Hsz_Vmcy-Y

b The cross-shaped structure of the tRNA molecule is the same for all tRNAs, but the amino acids that make up the chain are different. Only the red marked parts are the same in all tRNAs. The red-rimmed anticode portion is shown enlarged in ***Fig. 229*** p in connection with the code part of the mRNA

c http://book.bionumbers.org/what-is-faster-transcription-or-translation/

d https://en.wikipedia.org/wiki/Viroid

e Peptide nucleic acid (PNA), threose nucleic acid (TNA) of glycol nucleic acid (GNA). https://en.wikipedia.org/wiki/Peptide_nucleic_acid ; https://en.wikipedia.org/wiki/Threose_nucleic_acid ; https://en.wikipedia.org/wiki/Glycol_nucleic_acid

f https://en.wikipedia.org/wiki/Proteinoid

ENCLOSURE PROTECTS AGAINST EXTERNAL ENTROPIES

Metabolism and reproduction may be possible without enclosure

Enclosure with a membrane (***Fig. 197*** p225) or shell of chinin or chalk as in 'foraminifera'[a] is often seen as the first condition to give vulnerable life processes a chance in a chaotic environment. According to chemists from Nijmegen, however, this is not strictly necessary.[b] That is why I address this condition of life after the environment, metabolism and reproduction.

There are abiotic enclosures

In addition to the proteinoids, there are other abiotic-chemical reactions that form spherically sealed spaces ('microspheres').[c]

In such microscopic balls with semi-permeable walls, medicines are also packaged to be slowly released into the body.
Within such an enclosure a stable and deviant inner environment can exist.
If such a microsphere has a small opening (***Fig. 232***), then there a concentration gradient[d] with some sequential metabolism can emerge.

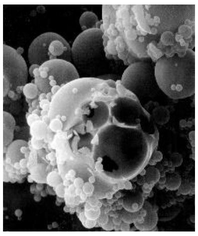

Fig. 232 Microsphere[e]

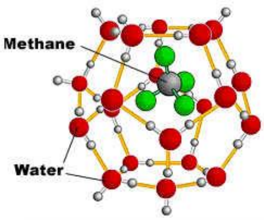

Fig. 233 Methane clathrate in water[f]

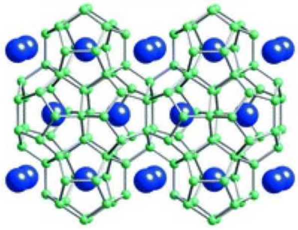

Fig. 234 Hydrogen clathrate in silicate[g]

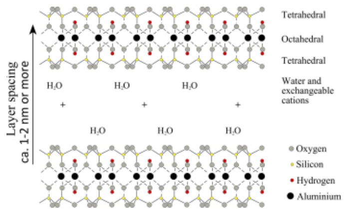

Fig. 235 Montmorillonite[h]

'Clathrates' are polymers that can enclose a guest molecule. The best-known example is methane, around which water crystallises into an ice-like polymer (***Fig. 233***).
When heated, the methane is released ('burning ice').[i] The supply of methane that can be trapped in water and exploited this way is enormous.[j]

Also CO_2 and H_2 can be trapped in water or other polymers this way without escaping as gas (***Fig. 234***).[k] The clathrate polymers can be quite large and enclose more guest particles. Organic concentrations in the freezing of water may also produce cavities.

a https://en.wikipedia.org/wiki/Foraminifera
b https://newscientist.nl/nieuws/cel-kan-bestaan-zonder-membraan/
c Fox(1958)Thermal Copolymerization of Amino Acids to a Product Resembling Protein(Science) 128 1214–1214
http://science.sciencemag.org/content/128/3333/1214
d https://nl.wikipedia.org/wiki/Concentratiegradi%C3%ABnt#Ori.C3.ABntatie_in_een_concentratiegradi.C3.ABnt
e https://www.stevenbrooke.com/bio/steven-brooke-biography
f https://kumpul4ntul1s4n.wordpress.com/2011/05/05/mencairnya-methane-hydrates/
g https://mrsec.org/highlights/storing-hydrogen-novel-clathrate-materials
h https://en.wikipedia.org/wiki/Montmorillonite
i http://www1.lsbu.ac.uk/water/clathrate_hydrates.html
https://www.reddit.com/r/chemicalreactiongifs/comments/58n5hy/fire_ice_a_methane_clathrate_looks_like_a_chunk/
j https://en.wikipedia.org/wiki/Methane_clathrate
k http://www.slideserve.com/wren/hydroquinone-clathrates-for-fuel-cells-sachdeva-et-al-ecs-trans-2010

The common type of clay montmorillonite (***Fig. 235***) consists of small plate-shaped crystals with which air bubbles can be enveloped in water. If they come into contact with simple organic compounds with a lower surface tension than water eg ethanol, the plates are enveloped with them and form an adherent, semi-permeable armor.

The air in the bubble dissolves outwards, and the surrounding water can enter with organic components while the armor holds.
Montmorillonite catalyses lipids into membranes and single nucleotides into RNA chains. The semi-permeable wall does not allow these larger structures to escape outward, but remains open for the supply of smaller external components.[a]

So, different kinds of enclosure may have preceded the formation of the now generally occurring membranes (***Fig. 197*** p225).

a Subramaniam(2011)Clay-armored bubbles may have formed first protocells(Cambridge Mass)Harvard University https://www.eurekalert.org/pub_releases/2011-02/hu-cbm020411.php

§ 40 ORGANISMS ORGANIZE

CELLS MULTIPLY

If the conditions of environment, metabolism, reproduction and enclosure are met at the chemical level, then life has cells that can differentiate and compete, the two conditions for natural selection and evolution.

Developing different forms of metabolism, reproduction and enclosure, they can survive in different environments, fulfill different functions in a larger body, raising the scale of external competition by internal cooperation.

Cells group, differentiate, enclose, reproduce, ungroup and compete

From the thousands of 'mucus fungi' described, the species 'Dictyostelium discoideum'[a] provides a nice picture of the way in which individual cells can group together into an organism, receive a division of tasks ('cell differentiation', ***Fig. 236***) and reproduce socially as well as sexually and vegetatively (***Fig. 237***).

Dictyostelium discoideum has long been regarded as a fungus, but it turns out to be an amoeba, a cell with a nucleus ('eukariote') and a flexible cell membrane that can extend to sham feet ('pseudopodia') and move along solid ground.
The amoeba feeds on bacteria and propagates vegetatively through cell division ('mitosis', ***Fig. 236***a).

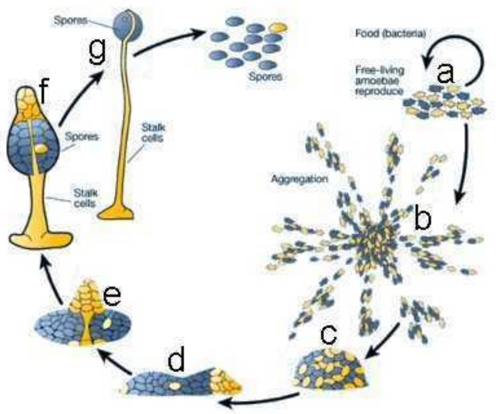

Fig. 236 Social reproduction and differentiation of Dictyostelium discoideum [b]

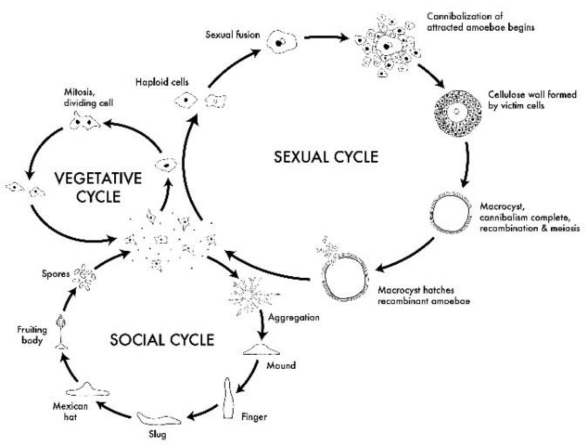

Fig. 237 Reproduction methods [c]

If starvation threatens, then the amoebae produce cAMP as a signal substance.[d]
Around 100 000 scattered cells then move towards a point with the highest concentration of cAMP (***Fig. 236***b).
There they attach themselves to each other as a 'pseudoplasmodium' (***Fig. 236***c).
This organism takes the form of a snail of 2 to 4 mm long (***Fig. 236***d).

a https://en.wikipedia.org/wiki/Dictyostelium_discoideum
b Shaulsky http://dictybase.org/Multimedia/index.html
c Brown http://dictybase.org/Multimedia/DdLifeCycles/index.html
d ATP and ADP have three and two phosphate groups (***Fig. 195*** p93). AMP has the same basis with one phosphate group. cAMP is a variant of this.

This snail can move to the light and more nutrient-rich area as a result of secreting cellulose at the front as a lubricant which remains behind on the bottom as a snail trace. Arriving in a nutrient-rich area, the cellulose-producing cells move within the organism to the middle and vertically upwards (***Fig. 236***e) making a stem.

They strengthen the stem with cellulose on the outside. The other cells move upwards (***Fig. 236***f). The stem is extended from below as long as enough cellulosic cells remain, to attach the organism to the soil. At the top, the other cells dry out into spores with DNA, which are released in order to become new amoebae (***Fig. 236***g).

Sexual reproduction is a risk coverage
In case of food scarcity, the individual amoebae can also breed sexually (***Fig. 237***).
If a male and female cell are united ('zygote'), then as a unit they can catch surrounding amoebas, enclose them in a cellulose shield and use them as food ('cannibalism').

One large closed cell ('macrocyst') is created in which the male and female genes are 'recombined' ('meiosis' with 'cross-linking').
With that DNA, new amoebae are assembled and released.

In sexual reproduction of higher animals, the first cell is usually formed by meiosis, the combination and recombination of male and female 'gametes' with single ('haploid') DNA chains, into a 'zygote' with recombined and doubled ('diploid') DNA chains that form each other's negative.

After meiosis, cell division is vegetative (mitosis). In small organisms, the cell with the recombined DNA can divide within an hour, and the resulting cells again.
Within 4 hours that is a clump of $2^4 = 16$ cells ('morula' ***Fig. 238*** p248).[a]
At further growth to 2^7=128, cells move to the outside, creating a cavity.
It is then enclosed by a wall of cells ('blastula' ***Fig. 238***).

For some species of green algae (the genus Volvox[b]) such a blastula colony is already capable of reproduction. In the hollow sphere, there are indentations with new cells that loosen per 16 in the cavity and develop further with whip hairs until the old sphere falls apart. Then they can swim out.

A critical event is cell polarization which enables cells to migrate, differentiate and organize different body parts, resulting in complex organisms with a multitude of cell types that have diverse functions.

In animals, embryo polarity is essential feature for its development. Tissue growth depends on the polarized activity of cells which is preseved by the controlled orientation of division axis. Intrinsic polarity cues of a cell in most tissues determines the cell fate.

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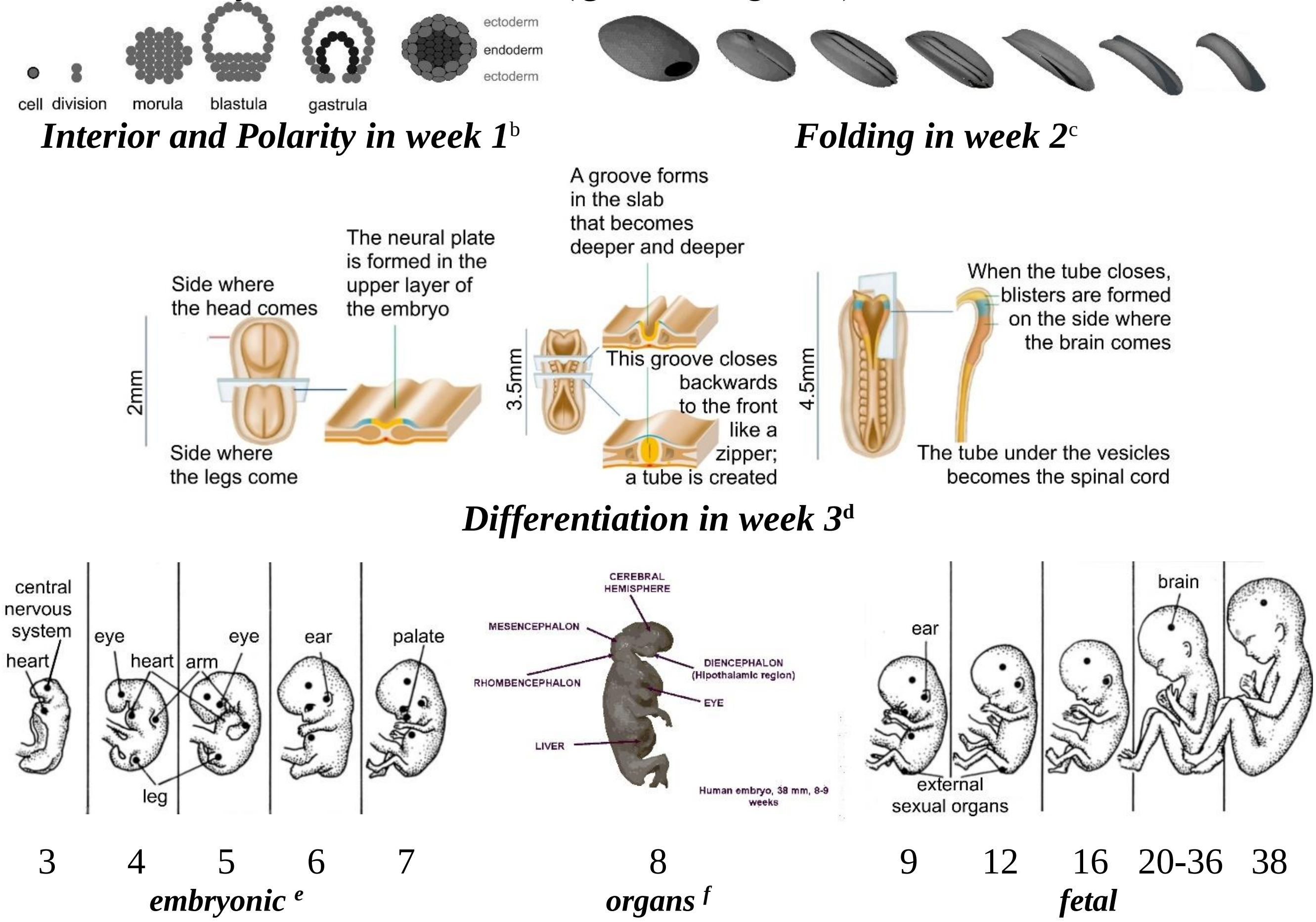
a http://tunicate-portal.org/faba/1.4/document.html
b https://en.wikipedia.org/wiki/Volvox

Already on the first day of the process in which an organism is formed by division from the first cell ('embryogenesis'), 'polarity' is the origin of cell differentiation.[a] Within individual cells, there is already a task-distributing orientation for the division ⊥ the division plane, due to the location of the poles that pull the DNA apart.

ORGANS SPECIALIZE

Function follows form

In the blastula, some cells concentrate on one side.
On that side they form an indentation ('gastrula' ***Fig. 238***).



240 Gastrulation producing interiors of
240 Embryo.xar

Fig. 238 Embryogenesis in humans per week

At the opening of the gastrula the outer skin ('ectoderm') changes into an inner skin ('endoderm'). It gets other tasks (for example as a gut wall). The senses will arise on the transition between the two. From there the neural system will develop. The 'lips' extend in five days at the back to a 'neural groove' or 'neural gutter'.[g]

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a Sinnott(1963)The problem of organic form(New Haven)Yale University Press considers polarity and symmetry as the first form principles in all living organisms.
b http://www.gastrulation.org/Movie13_1.mov
c https://www.youtube.com/watch?v=aOY16GlqrPw&feature=youtu.be
d http://www.natuurinformatie.nl/nnm.dossiers/natuurdatabase.nl/i004900.html
e http://opleid.info/1eerste-week-na-de-bevruchting.html
f By Anatomist90 - Own work, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=18391191; http://www.visembryo.com/baby/; http://embryo.soad.umich.edu
g This can be seen in http://www.gastrulation.org/Movie13_1.mov. This film gives a picture of the gastrulation and further development of a frog.

The rest fold around this neural gutter into a neural tube (***Fig. 238***, if it does not close properly, then the child can be born with an 'open back'[a]). Inside, the muscles, skeleton and skin will be formed (on the 'dorsal side' of the back).

On the ventral side ('ventral' belly side) there is a cell complex ('mesoderm') between the inner and outer skin that will form the organs for metabolism, blood circulation and so on.

The question is, of course, how cells (with exactly the same DNA) 'know' what to do in all these different parts and organs of the organism. They receive enzymes and signal substances, 'hormones' to locally and temporarily set up the right processes. They have to give signals themselves to spur other cells and get signals from their environment to address the right parts of their DNA on the spot while others do not.

In humans, the first week of cell divisions of the embryo can be followed during test tube fertilization ('in-vitro fertilization').[b]

Form follows function

Three days after fertilization outside the body, there must be an 8-cell embryo that can be replaced in the uterus. After 15 days, the embryo is nearly half a millimeter large and visible in detail from the outside with scans. From that 15th day, the development is documented in detail three-dimensionally interactively per body function.

On the 15th day (0.43mm) only the endoderm on the abdomen side, the ectoderm on the back and the neural tube in between are shown in ***Fig. 240***.

On the 17th day (0.61mm), a brood bag has been developed at the endoderm on the belly side (left out in ***Fig. 240***). At the back, the mesoderm becomes visible between endo- and ectoderm in flat, banana-shaped peels.

On the 19th day (1.6mm), the onset of skeletal, muscular and nervous systems can be recognized on the back and the beginning of metabolic blood circulation and other organs on the abdomen side.

On the 23rd day (2.5mm) the first signs of sense development are added at the top. In the months that follow, a fascinating process of growth and differentiation of our organs unfolds.

A considerable body of knowledge has been accumulated over the years on microscopic embryos of other species. In the sea, various types of 'sea squirts' grow, which propagate through a larval stage. The embryonic development of the first days of the 'Ciona intestinalis' type is described in detail (***Fig. 239***).

238 embryo mens en zakpijp.xlsx

a Perhaps a split cleft lip is also due to this. This sometimes continues to the palate and perhaps further into the brain and back. https://en.wikipedia.org/wiki/Cleft_lip_and_cleft_palate#cite_note-CDC2014-1
b https://nl.wikipedia.org/wiki/In-vitrofertilisatie

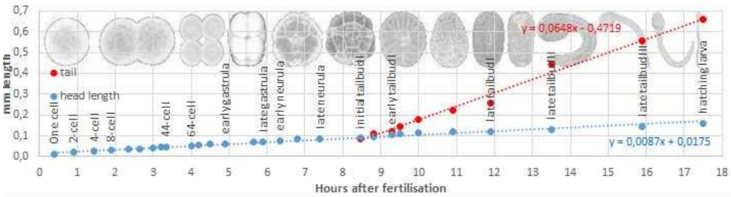


Fig. 239 Ciona Intestinalis grows 0.5mm in 15 hours[a]

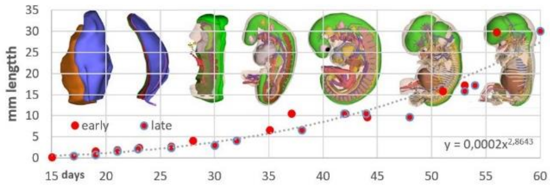


Fig. 240 …a human only after 15 days[b]

The cell division of Ciona intestinalis starts half an hour after fertilization, gastrulation after 5 hours, the development of a neural system after 6 hours.
The tail begins to grow after 8 hours and after 18 hours the larva is ready for its task. Humans require 9 months and then a long education.

Task division requires signals

The division of tasks between cells and organs in an organism is controlled by signal molecules.[c] They spread from sending cells in the fluid between cells and organs ('plasma') in decreasing concentration ('gradient'), or via the circulatory system throughout the body.

They are transmitted by receptors in the cell wall of receiving cells as a message to the liquid within the cell ('cytoplasm'). There they stimulate the right enzymes to their specialist activity.

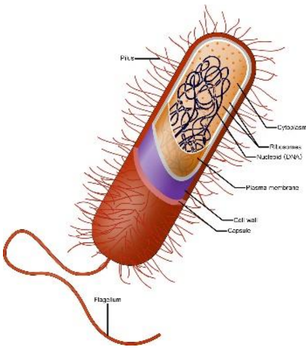
Signal substances can be produced by special glands and spread all over the body or in a single organ (hormones), by different cell types locally to their neighbors or spread throughout the body ('cytokines'), between senses, nerve cells ('neurotransmitters') and muscles and other cells, or stimulate other organismes outside the sending organism ('ectohormones' such as 'pheromones').[d]

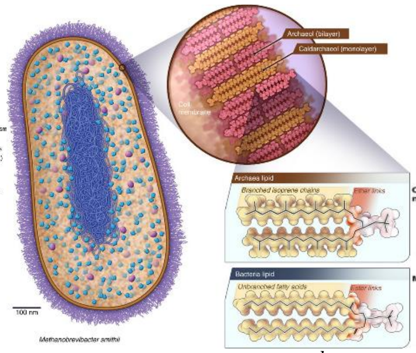
ORGANISMS DEFEND THEMSELVES AND REPRODUCE

Prokaryota use one outer defence wall

Unlike organs, organisms are directly exposed to a changeable, sometimes aggressive outdoor environment. Primitive single-celled organisms ('prokaryota', including bacteria and archaea) protect themselves against that environment and against loss of their composition, by a usual two-fold membrane ('bacteria' ***Fig. 241***), a single membrane ('archaea' ***Fig. 242***) or chalk shield.

a http://tunicate-portal.org/faba/1.4/document.html
b http://virtualhumanembryo.lsuhsc.edu ; https://www.3dembryoatlas.com/
c https://en.wikipedia.org/wiki/Cell_signaling
d https://nl.wikipedia.org/wiki/Signaalmolecuul





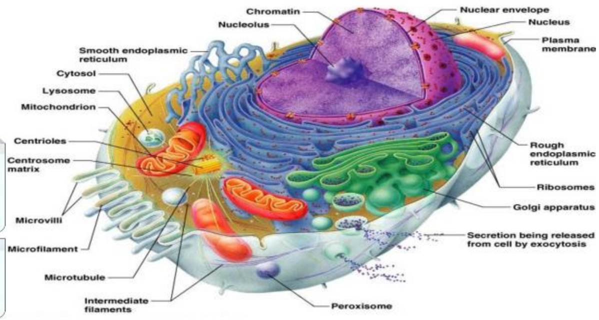


Fig. 241 ***Bacteria***[a] *Fig. 242* ***Archaea***[b] *Fig. 243* ***Eukaryota***[c]

In addition, they still have protective layers, hairs and sometimes a whip ('flagella') to move on.

The DNA of both is a closed ring, supplemented with loose DNA rings that can be exchanged with other prokaryotes ('plasmids'[d]).

Prokaryotes rapidly divide (mitosis within 10 minutes) and also can rapidly change due to that plasmid exchange. In bacteria, the DNA is spread throughout the cell, but archaeae concentrate it in a nucleic nucleotide without membrane or supporting protein ('chromatin' as in 'eukariota'). Both have loose ribosomes, but the protein production of archaea is more like that of eukaryota than that of bacteria.

Eukariota use also inner walls

The third group of organisms (the one-cell or multicellular 'eukaryota'[e] to which we belong, ***Fig. 243***) have organ cells ('organelles', the cell nucleus, ribosomes, mitochondria and the like) that also have a membrane themselves.

This results in more stable and protected environments suitable for more different processes. Multicellular eukaryotes develop also an all-embracing defensive skin and, within them, individually enclosed organs.

The approximately one and a half million species of organisms that we know and have described are perhaps only one tenth of the number of undiscovered and undescribed species. The number of extinct species that has ever existed is probably another hundred times as large.

LUCA is a hospitable common ancestor

The hypothetical common ancestor LUCA reconstructed from the common denominator of existing DNAs has had numerous extinct predecessors.

The ribosome (the protein factory p224) occurs in all organisms after LUCA.
It is not made by enzyme proteins, because they must first be made in ribosomes themselves.

a https://en.wikipedia.org/wiki/Bacteria
b https://en.wikipedia.org/wiki/Archaea
c https://patriceayme.wordpress.com/2015/05/
d https://en.wikipedia.org/wiki/Plasmid
e https://en.wikipedia.org/wiki/Eukaryote

It contains rRNA chains with its own recipe and reproduces itself without having to consult a DNA library. It thus contains hereditary material outside the DNA (such as the plastids on p243 in a bacterium), which replicates alongside the DNA during cell division ('extra-chromosal heredity').[a]

The ribosome may have had a precursor to LUCA that has consisted exclusively of RNA (RNA world) without protein components.

Something similar also applies to other organelles in the cell. In this way, the 'centriola' spinning the wires that have to pull the DNA apart also reproduces itself without a prescription from outside. The mother and daughter centriola move to two poles before cell division.
In addition to this role in cell division, they also make a 'flagella'.

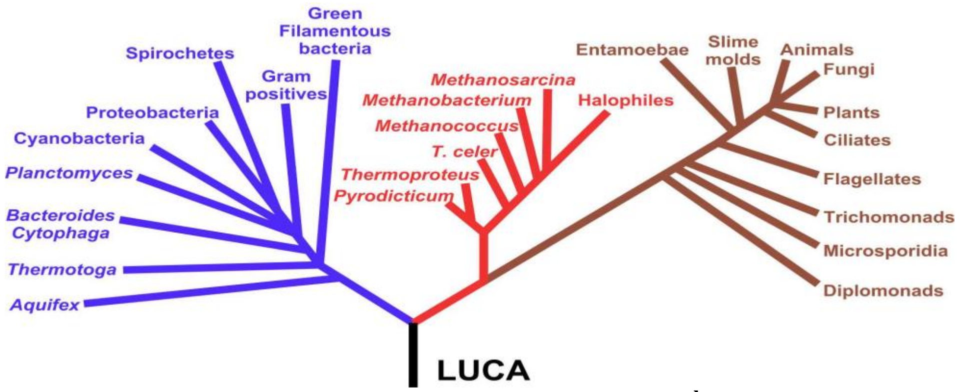


Fig. 244 Phylogenetic family tree[b]

The mitochondrium (the energy factory p219) has a two-fold membrane and its own genes with which it makes its own proteins and reproduces.

It is also considered a bacterium that has ever crept into LUCA, adapted, and made itself indispensable in all eukaryotic cells.
In plants, the double-walled chloroplasts for photosynthesis (***Fig. 204*** p230) are regarded as entangled plastids that share their own authority.

ECOLOGY BALANCES BETWEEN COMPETITION AND COOPERATION

The microbial mat is a prototype of cooperation

The microbial mat (***Fig. 228*** p241) is a prototype of cooperation between organisms ('symbiosis') on the border of two very different environments: the dark mineral world from a solid, safe soil to that of the changeable water or the open, light-filled air.
The different organisms live in layers. They could not survive on another 'floor', and they pass on products in two directions that they themselves cannot make.

In the wide variety of environments in which the earth supplies under water and on land ('habitats'), various forms of cooperation arise with different kinds of task

a Jinks(1964)Extrachromosomal inheritance(Englewood Cliffs)Prentice-Hall Inc
b https://nl.wikipedia.org/wiki/Fylogenie

division. All manner of concentration gradients[a] of food and signal substances[b] are required for this division of tasks.

In the first oxygen-free ('anaerobic') environment, where no photosynthesis (p229) could release the necessary carbon C from carbon dioxide CO_2 (with oxygen O_2 as a waste product that would change the atmosphere), had been another source of energy than light or oxidation with oxygen required.

Bacteria and archaea that could use CH_4 or hydrogen sulphide H_2S (p240) were probably the first 'layer' or 'phase' of carbon and energy supply.

Competition stabilizes a population by fluctuation
Ecology includes not only *cooperation*, but also *competition* within the species, *competition* with other species and robbery ('predation').

Predators prevent the overpopulation of their prey. If, however, the prey population becomes smaller, then *predators* will die, and the prey population can again expand. This leads to a fluctuation of both mutually alternating populations ('population dynamics' ***Fig. 245***) that can be mathematically simulated (p150).

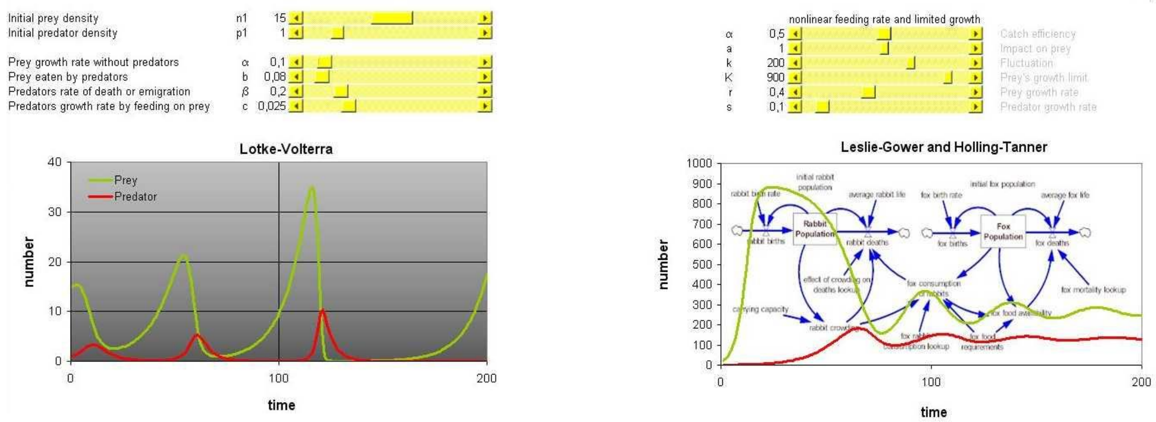


Fig. 245 Predator prey simulations[c]

Such a negative feedback prevents exponential growth of herbivores that would lead to habitat depletion. It keeps their population within bounds, but it also accelerates the evolution of both populations by killing the inaccurate specimens.
This accelerates the 'survival of the fittest' and increases their living space.

Preys have adapted in many ways to survive in an aggressive environment.
They have strengthened their skin (sometimes patched, hairy or spiked), movement organs developed to be able to flee or defensive organs to fight. They have developed an immune system[d] against aggressive micro-organisms, fearsome signals or poisons against other aggressors.

a https://nl.wikipedia.org/wiki/Concentratiegradi%C3%ABnt#Ori.C3.ABntatie_in_een_concentratiegradi.C3.ABnt
b https://nl.wikipedia.org/wiki/Feromoon
c https://en.wikipedia.org/wiki/Lotka%E2%80%93Volterra_equations ; http://www.sciencedirect.com/science/article/pii/S0022247X09004442
d Oskam(1972)Infektie en immuniteit(Utrecht)Spectrum Aula

The human population has disabled its predators
The human population now has few other predators than its members (competition). Its *habitat* then limits its exponential growth by exhaustion (the logistic curve ***Fig. 125*** p152 or ***Fig. 128*** p153).

Overpopulation may cause a chaotic period of decline and ascent due to floods, water and food shortages (phosphor), new diseases as predators (corona) or wars (***Fig. 130*** p153). The 'fittest' (read 'richest') will survive.
A *stable* sustainable population (8 billion?[a]) requires birth control.

Cooperation requires signals and receptors
The most common kind of cooperation ('symbiosis') is the sexual.
Combining two gametes from different organisms creating a new zygote variant requires coordination in space and time.

For example, male moths have developed antennas that can detect even one molecule of a species-specific female pheromone at great distances.[b]
Through zigzag movements in the air they seek the higher concentrations that lead to the female. That pheromone is spread only when the time is right.

The basis of all food chains is the vegetation. Since plants usually cannot move, their sexual reproduction is dependent on massively distributed male gametes, which happen to hit a female gamete of the same species.

Specialized insects reduce that hazard, but in flowering plants the pistil receptors should be able to recognize and allow this gamete from countless pollen species.

In the cell, enzymes have equally accurate pattern recognition mechanisms through their shape (***Fig. 208*** p232). RNA demonstrates this ability in searching the DNA library and assembling proteins (***Fig. 229*** p243).

It also exists in the detection of incoming aggressive elements that activate our immune system. That alarm starts in our mouth and nose. The fabulous smell distinction in dogs is known, but plants also have such an alarm system.
They are even able to warn their neighbors with chemical signals.

Ecologies differ by level of scale
The local soil, vegetation and atmosphere, the local water and climate enable the habitat on which a local food pyramid of organisms can develop.
Ecology starts with the vegetation. Combinations of plant species are provided with different names at different scale levels (***Fig. 246***).

Biomes are appointed on a global scale. In 'biotopes' with a nominal radius R = 1km (approx. 300m-3km) components r=300m (approx. 100-1000m) are distinguished as 'communities' ('synecology').[c] For each species ('autecology'), for example, a different

a https://academic.oup.com/bioscience/article/54/3/195-204/223056 Fresco counts on 10 mld: Speksnijder(2018)Fresco(Volkskrant)0303
b https://nl.wikipedia.org/wiki/Concentratiegradi%C3%ABnt#Ori.C3.ABntatie_in_een_concentratiegradi.C3.ABnt
c For The Netherlands see Weeda(2000)Atlas van plantengemeenschappen in Nederland(Utrecht)KNNV

strategy for survival is observed ('ruderal', 'competitor', 'stress-tolerator')[a] or the chemical attractants and repellants that each species sets for this purpose[b].

The latter supposes insight on the smallest scale: biochemistry.
This immediately touches the broader field of signaling and pattern recognition mentioned above by enzymes and systems of reproduction. The steering effect ('cybernetics') of concentration gradients can extend from the distance between cells, until a nominal radius R = 10m (boundary environments) between organisms.

frame	abiotic frame	grain	biotic components	ecologies
kilometres radius (nominal)				
10000	earth	3000	biomen	Geography
1000	continent	300	areas of vegetation	
100	geomorphological unit	30	flora-counties	
10	landscape	3	formations	landscape ecology
metres				
1000	hydrological unit, biotope	300	communities	synecology
100	soil complex, ecotope	30	ecological groups	systems ecology
10	soil unit, boundaries	3	symbiosis and competition	cybernetic ecology
millimetres				
1000	soil structure and ~profile	300	individual survival strategies	autecology
100	coarse gravel	30	specialization	biology
10	gravel	3	integration	
1	coarse sand 0,21-2	0.3	differentiation	
micrometres (μ)				
100	fine sand 50-210	30	multi-celled organisms	microbiology
10	silt 2-50	3	single-celled organisms	
1	clay parts < 2	0.3	bacteria	biochemistry
0,1	molecule	0.30	virus	

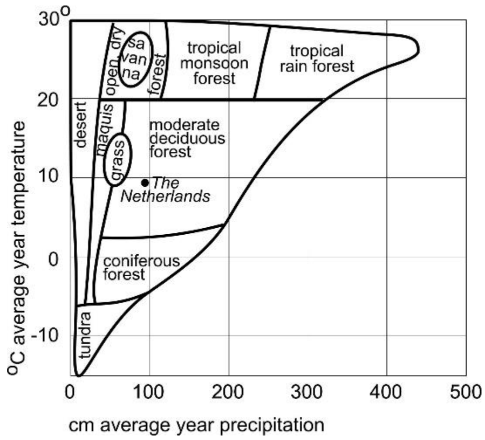


Fig. 246 Ecologies to level of scale[c]

Concentration gradients, decreasing concentrations of organic compounds, minerals, light, temperature, pressure and humidity (altitude) on different levels of scale, create an unlikely variety of environments, populated by an unlikely variety of suitable species and again a multitude of mutual relationships.

Biodiversity is a risk coverage

The rapidly declining biodiversity may entail the risk that crucial signals and nutrients will disappear from the biosphere, resulting in unrestrained epidemics.
Unlikely small quantities can be decisive.
They can easily escape our attention, so that we cannot know the crucial effect.

Before we have sufficiently understood these ecological relations, scientific modesty and restraint in generalizing conclusions is appropriate.

About one and a half million species are known and described.
There may be ten times as many unknown species and the number of species that has ever lived is perhaps another hundred times as large.

a Grime(1989)The abridged comparative plant ecology(London)Unwin Hyman distinguishes 'rapid growth, reproduction and clearing the field' ('ruderals'), 'slowly building up capital to overshadow neighbors and then propagate ' ('competitors') and 'specialize in locations where others cannot survive' ('stress tolerators'). The latter category can survive extreme temperatures, nitrogen shortages or long periods of drought. Grime quantifies the proportion of these three categories per species. This also means the conditions that characterize the environment for the applicants.

b Genderen(1996)Chemisch-ecologische flora van Nederland en Belgie(Utrecht)KNNV ; Barrington(1964)Hormones and evolution(London)The English Universities Press Ltd.

c Jong(2008)Sun Wind Water Earth Life Living Legends for Design(Delft)TU lecture paper p395, 373 http://www.taekemdejong.nl/Publications/2009/Territory59.pdf

In order to understand the operating of one species (humans), over 30 different medical diciplines exist, but our knowledge about how the human body and mind actually work is still limited.

Moreover, within a species each specimen is different and responds differently to environmental factors (signaling substances, medicines).
In order to complicate matters further scientifically, each copy ends up in a different context. Statistical generalization is then inadequate.

EVOLUTION SELECTS BY ERRORS

Without mutations, there would have been no evolution: we humans would not exist. However, the mutation rate of stable genomes is estimated to be 10^{-10} per base pair per cell division.[a] A mutation may be harmful, harmless or advantageous for survival.

Evolution by such improbable successful events, combined with the subsequent selection in different environments cannot be understood by generalizing with statistical means.

The chance is small, but the number of chances is large
A successful mutation is highly improbable, but the number of cells and selecting environments is unimaginably large.

An environment in which any metabolism can emerge spontaneously, does not mean that it will also happen within a foreseeable future (despite Murphy's law).
Spontaneaous generation is even not yet certain, if such an environment is maintained somewhere on earth in a million laboratories during a million years.

The earth, however, has had more laboratories over longer periods.
It is thought that such an environment around volcanoes has existed everywhere on ocean floors, when the earth's crust has been still thin and breakable.

Suppose that the laboratories were 0.3μm (the size of a small cell), distributed over 1,338 billion km^3 of water (the amount that is still present on earth), then there were 10^{37} laboratories. If one billionth of them had a suitable environment for a reaction taking 1 second, then there are 10^{28} reactions per second or $3*10^{36}$ per year on earth.[b]

If one billionth yields a suitable organic molecule, then there are still $3*10^{27}$ organic molecules that could be composed. The probability that 1000 molecules of that $3*10^{27}$ coincidentally are the right combination for the formation of a primitive organism in a billion years is difficult to calculate, but that coincidence is conceivable.[c]

On an even smaller scale you may imagine the possibility of emerging larger molecules as follows. Two particles flying towards each other, mainly result in collision or passing. Both result in divergent movements, scattering, increasing entropy. That change is purely mechanically irreversible.

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a Baer;Miyamoto;Denver(2007)Mutation rate variation in multicellular eukaryotes: causes and consequences(Nature Rev. Genet.)8 619–631.
b Shapiro(1986)Origins(New York)Summit calculates the number of proteins composed during the Earth's existence as 10^{51}.
c Kaufmann(1993)The origins of order(Oxford) University Press took the possibility of self organization into account

So, thermodynamics is not the only source of concluding irreversible time, and statistical reasoning is not necessary to give meaning to the concept of entropy.

There are, however, two special cases: the particles break into smaller diverging pieces on impact or they become connected as a larger particle that only disintegrates by external energy. That requires non-elastic deformation instead of repulsion, converting some kinetic energy into the potential energy of improbable shapes.

BIOLOGY HAS MADE GREAT PROGRESS IN RECENT DECADES

The emergence of larger (less elastic) molecules enables the origin of life.
We can presume a sequence from primitive to complex.[a]
We can date specimens found in the soil and compare their content, shape, structure, their DNA sequences, find the mutations, and determine their genetic distance matrix.

Then such evolutionary history can be reconstructed (using sequence alignments) into phylogenetic relationships, a tree-like structure reflecting the divergence of genes, species, or organsims that are assessed (***Fig. 244*** p252).

In the development of similar *forms* and *structures* we see separate organs appear, of which we can then reconstruct the *function*. This takes place from the experience with living organisms, which we consider as a temporary end point.[b]

For example, we can follow the evolution of hormone glands.
You then can understand the development of their product (eg cholesterol) as biochemical evolution.[c]

The comparison of sequences in the codes of the DNA with different species has made great progress in recent decades. This resulted in a rearrangement of branches in the evolution tree ('phylogeny', ***Fig. 244*** p252) previously only derived from successive organic forms and structures ('taxonomy').

The trunk is now LUCA, but we cannot see the roots.
We can only *reconstruct* them from differently presumed environments.

Nevertheless, the tree structure with vertical branches is not the whole story, because there are genes that have been exchanged (extra-chromosally), 'horizontally', between the branches outside the DNA of the chromosomes.

Plastids or whole bacteria that entered the cell became indispensable for its evolution. They reproduce on their own authority.
For example, in a branch suddenly complicated organelles from another branch can appear that cannot be inherited from their own ancestors.

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a With or thout suppositions of self-organization.
b At every point in the evolution it could have been very different with minimal changes in mutation and environment.
There are countless other evolutions imaginable. Within all these unlikely possibilities, ours is not by definition the most likely.
c Barrington(1968) gives a clear, readable and very different species including insight, but at many points he is certainly out of date. However, he immediately stresses (equally clearly) the provisional nature of these insights. That admirable modesty, dressed in a multicolored cloak of pure curiosity in science, now apparently falls prey to commercial competition compulsion. Any contemporary insight should as well be concerned as preliminary.

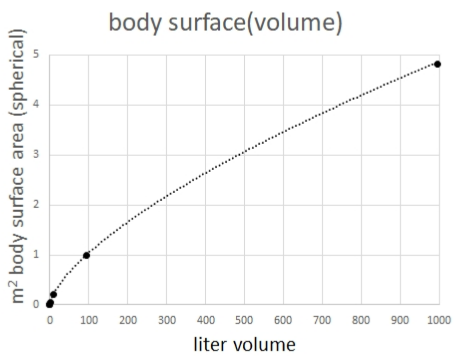
§ 41 BIOLOGY SUPPOSES A DESIGN

Fig. 7 p24 distinguishes modalities, levels of scale, context layers and object layers of design. Biology then exhibits the following design features.

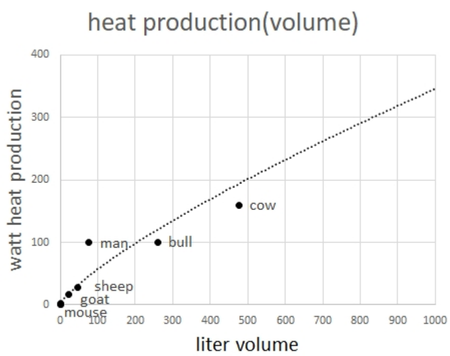
Modality ⇓ ((true⇒probable⇒possible⇒imaginable**)**∧desirable**)**
The modality of biology is primarily (im)**probability**, but its discoveries reveal **possibilities** that have not yet arisen in any human brain.

They originated in a time span that exceeds our **imagination**, trumping our design skills in finding unlikely possibilities. Life has achieved that by making endless mistakes in reproduction.
There was time to wait until one mistake became a operational design.
Individuals may have an innate **desire** to survive, but life itself is merciless.

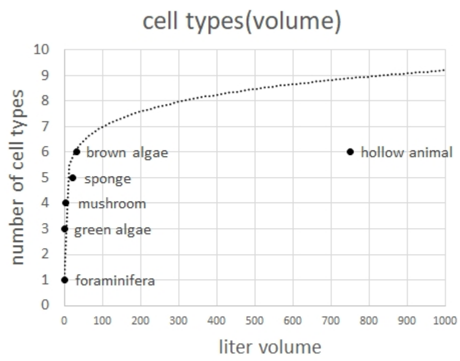
Levels of scale ⇓ (…,10m,3m,1m,…)
Fig. 246 on p255 gives an overview of 15 levels of scale with own variables on which living matter can be observed and studied. Grain and frame, however, show too large tolerances to connect with a nominal radius R.



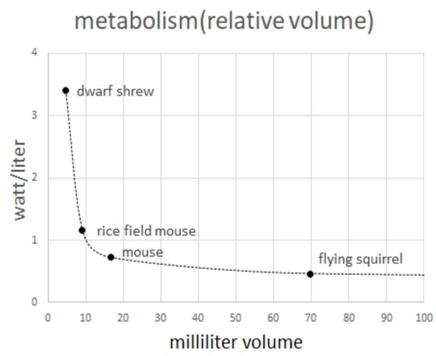
The body surface of animals is usually ca. 1.7 times larger than spherical, their weight in kg 1.05 times their volume in liters.



Heat production increases with size.



The number of cell types[a] increases to 120 in the largest animals.



Small animals use more energy per volume.

Fig. 247 Scale-dependent variables in animals[b]

a This distinction in cell types probably goes no more in detail than functional main groups such as muscle cells, nerve cells, cartilage cells, and so on.
b Edited to McMahon(1983)On size and life(New York)WH Freeman and Company p128,129,63,21.

The scale levels of biology are roughly the cell, the organ, the organism and the levels of organization. Organisms can be smaller than organs of a different species, such as the countless micro organisms that live in our intestines.

The smallest bacterium (Candidatus actinomarinidae) is 0,1μm, the largest animal (Balaenoptera musculus) 30m, the largest plant (Sequoiadendron giganteum) 110m, but a fungus (Armillaria ostoyae) can even reach kilometers.

With the size of the body the heat production and the number of cell types also increase, albeit to a decreasing degree. Per kg of body weight the metabolism from the smallest animals decreases rapidly, with the larger slower (***Fig.*** 247).

Limits to the size of organisms are set by gravity (which, for example, requires a skeleton) and the limited speed of chemical (information) exchange between remote organs. A small size has advantages for food supply, mobility and speed of reproduction. As long as extraterrestrial life has not yet been found on larger planets, the earth is the largest scale level R = 6378 km to which biology relates.

Context layers ⇓ (Abiotics ⇑ Biotics ⇑ Technique ⇑ Economy ⇑ Culture ⇑ Governance)

Abiotics limit the conditions for Biotics, but this *restriction* is at the same time an *extension* of physics, a selective, locally entropy-lowering metabolism that protects and reproduces itself.[a]
You may conceive the ABC model of ***Fig. 8*** p26 as layered: in two dimensions it limits (R = 7Mm, r = 0,1μm), but it extends in the third dimension.[b]

How the Biotic layer is 'mounted' on the Abiotic is astonishing.
Coincidence has made an unlikely small opening in the Abiotic layer.

Above that, a world of unimaginable diversity (in relation to the known Abiotic universe) has been realized. That *possibility* was contained in the Abiotic layer, but its realization demanded a series of unlikely events.
Which possibilities are yet more enclosed in that layer?

Technique uses unlikely possibilities that were not yet realized in the Abiotic and Biotic layers, such as the invention of the wheel. Planetary orbits and rotating parts in organic molecules may be precursors, but not wheels or gears at scales in between. Our technique, production and medical action, however, is still largely based on techniques already realized in the Biotic layer (materials, fossil or living, food).

The current world population is kept alive by an **economy** using (agricultural and industrial) techniques at a non biotic scale.
Overpopulation is enabled by technical inventions. Technology made it possible, but the abiotic and biotic sources of existence set their limits.

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a Dennett(2018)From bacteria to Bach and back(London)Penguin p107: 'discriminating differences in themselves and their immediate surroundings'.
b Schrödinger(1948)What is life(Cambridge)University Press; Gell-Man(1994)The quark and the jaguar(London1996)Little Brown & Co

Energy can still be extracted from the sun without excessive CO_2 emissions, but there is no technical solution for the next crisis of phosphate shortage.

The richest will survive, the rest will disappear unseen and unheard.
The natural selection ruthlessly performs its ordinary work, with the rich as robbers, the optimist as their spokesman and the free competition as their justification.
No culture exists without an economy by which its representatives survive.

Culture requires an economy that carries it and in turn bears a **government** that intervenes in all underlying context layers such as nature. The current biodiversity and dispersion of biotics cannot be understood without the antropogenetic effects.

Object layers ⇓ (Content ⥣ Form ⥣ Structure ⥣ Function ⥣ Intention)
The biotic **content** of elements is smaller than the abiotic content (§ 37 p216).
In that sense, biology is more limited than physics and chemistry.

At the molecular level, however, the number of combinations (compounds of elements) is greater, and at the level of organelles, cells and organs even much larger. The diversity with which biology is confronted is unimaginable.

The **form**, the dispersion of one or other content at any scale, plays a greater role in biology than in physics.

At the scale of the organism, it is expressed in the body surface, by which species are recognizable in their unimaginable variety. In proportion to the encapsulated volume, the sphere has the smallest, and therefore least varied, surface.
Every deviation at the same volume increases that surface (***Fig. 247*** p258).

At an ecological scale, specialized territories and habitats are separated in space, saving rare species for extinction.

The external **function** of individual biological objects is survival, reproduction and self-defense against abiotic and biotic threats. This requires internal functions, organelles and organs for material and energy supply, reproduction and protection. They are steered and maintained by a **structure**. At the smallest level it is a system of membranes and the internal 'cytoskeleton'.

The biotic conditions may not have their own **intention**, but they do have functions, structures, forms and contents. To *understand* biotics, out of bewilderment and curiosity, or in order to survive, is a *human* intention.

BIOLOGY CAN BE CONSTITUTED

Is biology constitutable according to ***Fig. 13*** on p37? It reads:

A	difference	⇑ change	⇑ coherence	⇑ selection	⇑ combination	⇑
B	metabolism	⇑ regulation	⇑ organization	⇑ specialization	⇑ reproduction	⇑
C	information	⇑ security	⇑ affection	⇑ identity	⇑ influence	

Biology must take into account more **differences** than differences in place, time, direction, mass and so forth in physics, and even more than the differences in the vast multiplicity of organic compounds in chemistry.

This combinatorial explosion of differences repeats itself to the scale level of the millions of species separately and their ecology. Moreover, *within* the species all individuals differ and their behavior also differs per environment.

Without differences in the environment and accordingly adapted different life forms, life would have had no 'choice' during the great changes in the earth's environment and would have been quickly died out. Biodiversity is a risk cover for life.

Something similar therefore applies to the **changes** at every level of scale in time. Evolutionary changes in the species you measure in millions of years, local adaptations in centuries, growth in years or hours, behavior in seconds.

The environment changes with the seasons, the rhythm of day and night and the weather. This does not tolerate mechanical determinism. Statistics have less control over the biological predictability in the long term, than on the weather.

Biological **coherence** supposes 'duration' in all these changes.
Feeding, reproducing and defending and their effects in the whole organism (heartbeat, in and out, sleeping and waking) and beyond continue as 'continuous' periodic repetition. Coherence ⇓ difference in change.
Chemical and organic processes ('physiology') follow a periodic cycle (***Fig. 206*** p231) of degradation and build-up in the structure ('anatomy') from cell to ecology.

These processes **select** with their selective input and output inside and out (the lungs, the digestive system and the kidneys select what is or is not usable for the organism). The secreted products are again selected by other species and brought together in new combinations. Selection ⇓ difference in coherence.

Selection is a key in the development of life at every level of scale, not only in the well-known Darwinian natural selection, but also in the rare selection of elements concentrated in an environment with the right temperature, pressure, supply and discharge making the **combination** of living matter possible (***Fig. 214*** p235). Combination ⇓ difference in selection.

So far, differences, changes, coherence, selection and combination are successively abiotically *possible*, but that possibility is further exploited and used biotically.
The absorption of external sources, the **metabolism** of (a)biotic combinations outside

the organism into the internal biotic, organic combinations, enables the difference of death and life (Δentropy). Metabolism ⇓ difference in combination.

The **regulation** of that metabolism is Maxwell's demon[a] who closes the valve if the entropy can come in and opens when it can get out (eg ***Fig. 205*** p230). Regulation ⇓ *change in metabolism* by cells, organs and organisms resisting their environment.

If cells join into an organism (***Fig. 236*** p246), then their individual arrangements must be organized. **Organization** ⇓ *coherence in regulation*.

Specialization (⇓ *selection in organization*) is another condition for organelle, cell or organ differentiation. This division of tasks enables production for the benefit of other cells and for **reproduction** of the organism as a whole.
Reproduction ⇓ combination in specialization (eg male and female).

a Knott(1911)Life and scientific work of Peter Guthrie Tait(Cambridge)University Press p214 https://archive.org/details/lifescientificwo00knotuoft :
"In an undated letter, which must have been written about this time (1867), Maxwell constructed the following Catechism:
Concerning Demons.
1. Who gave them this name? Thomson.
2. What were they by nature?
Very small but lively beings incapable of doing work but able to open and shut valves which move without friction or inertia.
3. What was their chief end? To show that the 2nd Law of Thermodynamics has only a statistical certainty.
4. Is the production of an inequality of temperature their only occupation? No, for less intelligent demons can produce a difference in pressure as well as temperature by merely allowing all particles going in one direction while stopping all those going the other way. This reduces the demon to a valve. As such value him. Call him no more a demon but a valve like that of the hydraulic ram, suppose."

10. CULTURAL CONDITIONS SELECT SUPPOSITIONS

§ 42 CULTURE SUPPOSES SHARED SUPPOSITIONS AND CONDITIONS

CULTURE SUPPOSES ABIOTIC AND BIOTIC CONDITIONS

On p25 'culture' is defined as 'set of shared suppositions and material conditions'. That involves more than the usual set of 'norms and values' in cultural anthropology[a] and sociology[b].

In this chapter culture is intended in a broader sense. It includes abiotic and biotic conditions, techniques and economics, as it is primarily recognized by archeology.

The archeologist should be able to distinguish human remains from anything else. A wooden pole or a flint should show signs of human *technique*, indicating their use in any past abiotic, biotic and economic context.
Geology may reveal details about the abiotic context (on the coast, a river or inland, on sand or clay). Ecology may reveal human livelihoods and possible economies.

Plants cannot move. Each plant is bound to its specific environment.
It has genetic recipes to survive limited fluctuations in that environment ('ecological tolerance', ***Fig. 11*** p29). Its cells receive messages by which they choose the recipe from the genetic library for appropriate adapation. They can specialize.
They also send each other messages with a distribution of tasks as a result ('cell differentiation', ***Fig. 236*** p246), but you do not have to suppose a shared culture.

Animals can move. They can search for an environment in which the ingredients for their specific needs are available. In addition to the chemical informatics of plants, they have advanced organs to receive rapidly changing information and to respond conformingly. In order to transmit signals (mainly to lure or chase away), they use movements and sound. You still do not have to suppose a shared culture either.

In addition to these means for survival by limited own adaptation, people and some animals have the ability to supplement their recipe with technical means in order to *adapt* themselves to the environment or even to *accommodate* that environment itself.

With these facilities they create technical conditions to survive differently in different environments. The discovery of utensils is therefore a proof for archaeologists of human presence in the past.

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a Daryll Forde(1934)Habitat, Economy and Society(London 1968)Methuen; already suggests in his title (according to me rightly) a conditional sequence. His 'ecological anthropology' sets the material ('habitat') and technical conditions first, as preconditions for divergent human cultures without becoming deterministic. Levi-Strauss(1955)Tristes tropiques(Paris)Librarie Plon , Mead(1959)People and Places(New York)The World Publishing Company , or Grottanelli ed(1965)Ethnologica - l'uomo e la civilta(Milan)SpA Edizioni Labor, give mostly separate descriptions of different cultures ('ideographic'), albeit sometimes per theme. Levi-Strauss(1962)La pensée sauvage(Paris)Librairie Plon then interprets 'culture' as a collection of unconsciously applied social rules such as the common incest prohibition ('structuralism', 'structuralist anthropology'). Kloos(1972)Culturele antropologie(Assen)Van Gorcum already has a more materialistic basis. Diamond(1997)Guns, Germs and Steel(New York)Norton is, however, a more recent example of ecological-cultural anthropology, which beautifully explains the environment and technology as a practical condition for still very different cultures.

b Doorn(1969)Moderne sociologie(Utrecht)Spectrum Aula for example, follows Durkheim's rule that social phenomena can only be explained by other social phenomena. I do not share that circular view, as well as the linguistic limitation of language philosophy: Boomkens(2011)Erfenissen van de verlichting Basisboek Cultuurfilosofie(Amsterdam)Boom p209 and the limitation to an upperclass of Elias(1939)Uber den Prozess der Zivilisation. Soziogenetische und psychogenetische Untersuchungen(Basel)Haus zum Falken. More attention to material, technical and economic conditions has Gurvitch(1967)Traité de Sociologie(Paris)Presses Universitaires de France .

CULTURE SUPPOSES TECHNICAL CONDITIONS

The art or skill ('technè' in Greek) to imagine a 'means' between the immediate need and its fulfillment (p31), requires an ability to imagine that provision between two objects, actions or status (three in one image), before an eventual realization.

That imagination then can be extended by many previously learned or developed (largely unspoken) *suppositions*, built up gradually in a *conditional* sequence. Transferring the suppositions of a culture to the newcomers (education) is a first condition of culture itself. It firstly requires abilities, techniques (manipulating, walking, speaking, listening, applying), before norms and values can be taught.

The Latin origin of the word 'culture' means 'care', 'building' and in particular 'agriculture'. Agriculture is a 'neolithic' *invention* with major consequences.
Its locally bound ('sedentary') way of life demanded more defense and planning for sowing and harvesting, breeding and slaughtering roaming than hunting and gathering.
The land was brought 'in culture' and regarded as occupied 'possession' ('territory').
It was more closed off from a otherwise little known 'barbarous' outside world.

CULTURE SUPPOSES ECONOMIC CONDITIONS

The properties of an individual or community are connected to a unique *identity*.
Individual identity ('difference with the rest and duration in itself')[a] is well known in a small family of hunter-gatherers or farmers, and so are the owners of some good.

In a small community (say 30 people) there are sufficient differences between origin, age, gender, appearance and behavior to be able to 'place' and distinguish somebody.
It enables to divide tasks according to each others abilities (specialization).
In addition, a common origin offers the individual a *group identity*, different from that of other families, tribes or communities. Identity has different levels of scale.

A commercial-industrial culture splits identity by higher densities.
In a large, crowded, mobile population, that individual identity is split into different roles in different groups with different subcultures of living, working, learning or recreating together.

Private ownership takes on the meaning of a mobile territory (prestige, authority)[b].
Identification with self-chosen idols reduces your own place in time and space, descent and origin, to an administrative identity ('name and address, please' asks a police officer).

Migrants with an agricultural background are 'elend'[c], 'out of the land' in an as yet unintelligible, barbaric world.
Without your own ancestral origin (family) or property (land), your own ancestral culture remains the only anchorage, a ground of group identity, a territory.

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a I associate "I" with a continuously repeated neural cycle (p50) with a consecutive set of suppositions of the self-image around a virtual point in which all subjective perspectives come together (p153).
b Jong(1978)Autoriteit en territorium(De As) zesde jaargang, nummer 31, http://www.taekemdejong.nl/Publications/1970tot1980/Jong(1978)AutoriteitEnTerritorium(Rotterdam)AS.pdf
c The etymology of the German (and Dutch) word 'Elend' (misery) is 'out of land'.

Forced 'integration' then is destruction of identity, a territory to be recaptured.
An undermined self-image cannot do more than searching for a group identity, a supposed *own* culture, justifying to conquer your place instead of being nobody.

Within the current commercial-industrial culture itself, there are similar identity-seeking remains from primordial cultures with a prehistoric tribal bond ('blood and soil'). Following the example of their idols (eg the scoundrels in the parliament), they sow hatred against the new competitors, harvesting hate the reverse.
Ascending conflicts set the clock back, but these help *their* lost identity in the saddle.[a]

This two-sided resurrected prehistoric relic refers to the dramatic transition from a more than 3 000 000 year long hunter-gatherer living into an agricultural existence ('neolithic revolution', some 10 000 years ago) and the resulting commercial-industrial culture in which the small communities dissolved.
That period covers less than 1% of human evolution. In such a short time the human nature has not yet been fully adapted to those revolutions.

a Identity, for example, also plays an important role in Elias(1965)The established the outsiders(London)Frank Cass & Co

§ 43 COLLECTORS MAP THEIR SPACE, FARMERS THEIR TIME

Mobile hunter-gatherers live day to day in a wide *space* (R = 10km) in which they have to know the way. Within the agricultural, smaller, isolated, uncluttered space of the occupied or inherited land (R = 300m) and the larger own 'property' acquired therein, there was more need for *time* division: a representation of seasons, storage for times of scarcity[a], an instructive past and a desirable future.

The division of space has a lower priority in a local agrarian culture.
In the annual flooding Nile delta of ancient Egypt, the land covered with divinely fertile sediment had to be reallocated, scaled, mapped and allocated each year.
The farmers did not do that themselves.
They leaved it to the surveyors of the godly Pharaoh. This prevailing subculture is more reminiscent of the fighters, hunters and collectors of the large space.

The (analytical) distinction between spaces and their division into different survival possibilities is more important for scattered hunter-gatherers than the division of time.

Between the two 'original cultures', you could presume a preferred development of either *analytical* or *causal* imagination (***Fig. 248)***, a different acquired capacity for overview or foresight.[b]

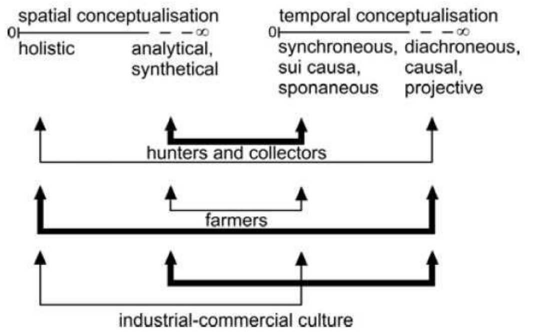

Fig. 248 Analytical and causal imagination

In the usually '*analytical*' representation of hunters and gatherers, the backward insight in periods of *time* is reduced to a synchronous, spontaneous, 'sui-causal' culture.
In addition to the '*causal*' representation of farmers, on the other hand, the insight into *space* is limited 'holistically' to its own small world.

A COMMERCIAL-INDUSTRIAL CULTURE DIVIDES TIME *AND* SPACE

Sedentary agriculture enables the exchange of surpluses, products, and thus trade with an increasing role for reliable, precise *calculation* and recording, *writing*.
The following commercial-industrial culture combines the classifying ability from both original cultures. This way of life requires a development of an analytical-causal 'if I buy this *here now*, then I will be able to sell it *there later on* with a profit'.

The holistic-suicausal connection, however, keeps an important, but subordinate role. In free time and space, an 'artistically-religious' counterculture remains active.[c]

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a This is especially true for seasonal grain harvests. In tropical conditions, many crops can be harvested all year round, but droughts can work like seasons again.

b This thought emerged from my own observation of the great differences between Indian and Creole villages and their inhabitants in Surinam around 1970. I assumed a recent past as hunters and gatherers among the Indians and a centuries-old agricultural background at the Creoles. There was no observable greeting or farewell with the Indians, but no reservations at meeting, at the Creoles though. These invited you for the meal in order to go preparing it. The Indians gave me a beautifully decorated boat without reserve and turned around without seeing how I would deal with them, as if they were not interested in whether they would ever get it back. Did the time to make a new boat play no role for them? Did 'possession' have so little meaning for them? They were also less concerned with death than the fears that the Creoles shared with me. Making appointments was also more difficult than with the Creoles.

c Roszak(1968)The making of a counter culture(New York)Doubleday&Company Inc describes how (in the 1960s) this counterculture could rebel.

For *hunters and gatherers*, this was a parallel causal-holistic counterculture of medicine men who can exorcise spirits, for *farmers* a parallel suicausal-analytical world of preachers and interpreters (***Fig. 2488***).

The commercial-industrial culture enables to live in many environments.
Fig. 248 schematises ideal types that you still can find mixed.
These are reminiscent of the three survival strategies of plants at Grime (note c p255): 'grow fast, reproduce and clear the field' ('ruderals'), 'slowly build up capital to overshadow the neighbors and then reproduce' ('competitors') and 'specialize in locations where others cannot survive' ('stress tolerators').
Michelson distinguishes comparable 'lifestyles' in the urban environment: 'consumers', 'careerists', 'familists'.[a]

You can situate the 'calculating and reasonable' commercial-industrial culture roughly in coastal areas with overseas trade and both prior cultures in the inland[b].

The origin of western civilization is generally situated in ancient Greece.
The large coastal length there, made the trade culture everywhere contrasting with relics of the original cultures in the interior.
Harvest festivals then have provided an annual confrontation.

I associate the elated, wine-drenched ancient Greek Bacchus cult with this crucial confrontation with a holistic-suicausal counterculture for Western culture.
'Bacchus (Dionysus) turned Apollo's head'.

The Bacchus cult caused resignation, ecstasy (ek-stasis, stepping out , see p17).
The bacchant stepped out its daily work in the inland and down to the coast. Masks hided its profession. This primal form of theater put daily life into perspective.[c]

This annual exercerise to move into another role became useful in the lessons of the Greek sophists. They first taught you to play the role of the opposing party before you make your own plea.
This objectivation also became the basis for Plato's dialogues and the scientific debate: an arbitrary division of roles between defender and opponent, regardless of whether you agree with the statement that needs to be defended or not.[d]

IDEAL TYPICAL CULTS OF COLLECTORS, FARMERS, PRODUCERS AND TRADERS DIFFER

In the ideal-typical hunter-gatherer, the deceased are good and evil spirits, that are still wandering around or taking place in physically present plants, animals or people.

Only the medicine man (the counterculture) knows their origins and can provide a good relationship with them by magic.

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a Michelson(1970)Man and his urban environment(Reading)Addison Wesley
b Fishery cultures take an ambivalent position.
c I do not share the interpretation of Nietzsche(1878)Die Geburt der Tragödie(Leibzig)Fritzsch.
d Jong(2001)De functie van stellingen bij het proefschrift(Delft)TUD http://www.taekemdejong.nl/Publications/2001/De functie van Stellingen bij het proefschrift.htm In academic promotions and court cases, people are still dressed to play a role that is separated from the person.

The killing and eating of 'inspired' animals could have the sacral meaning in order to to provide better housing for the deceased or incorporating their abilities.

The Scarab is an example of worship in ancient agricultural Egypt as a result of assumed spontaneous generation. That this beetle also lays eggs went unnoticed. Gods have no cause, they are their own cause ('sui causa').

For the ideal-typical farmer, plants, animals and people are in a causal time series of parents and ancestors, but these must have begun with something suicausal.
The deceased then move to that timeless space without cause and effect ('eternity').

Religion is mourning

Religion plays a role in almost all cultures. Why?
It cannot be explained solely by conceptual representations mentioned above.
The loss of parents will affect almost every person in every culture.

This is particularly drastic in times when parents died young and left young children. Religion then is the denial associated with a mourning process: the consolingly continuing life of ancestors in nature or in the eternity of 'our Father'.

From both primitive cultures I recognize remains in the current religious practice.
The role of *miracles* (magic) as a counterculture of causally compelling daily life, the representation of *God* and His earthly representatives as Allfather (holistic 'atavism'), *praying* as talking with your deceased (for) fathers or their union in God, the *guilt*, the *sacrifice* that repays them or Him, the *Communion* as a physical absorption of God's Son within yourself, the biblical *genealogies*, to know who are addressed.

Monotheism (one All-father) ended conflicts between tribes, each with their 'only real' own primal father. New wars arose when spokesmen of the common God, long after the first revelation, themselves were given a sacred status with interpreting and regulating authority (Catholics, Shiites). If that authority and its rules are challenged, a conflict arises with those who appeal to the original sources (Protestants, Sunnites).

WRITTEN WORDS EXTEND MEMORY

The revolutionary invention of writing, probably made a great impression at the time. The people went, the written words remained. The ideas behind those words seemed to lead a life of their own. They became 'flesh' in anyone reading them.

This undeniable repetition of ideas without humans gave written words something superhuman. What had been written from time immemorial seemed to be the evidence of ideas as an immortal higher reality preceding mankind.[a]

a Kraak(2006)Homo loquens en scribens Over natuur en cultuur bij de taal(Amsterdam)University Press, argues that the writing does not follow your thoughts as is generally assumed ('display myth'). Your thoughts follow the way you can write them down. We have become 'literate' at school.
I do not share his claim that the alphabet is not based on sound reproduction, but that our thinking is forced into a straitjacket as soon as we learn to read and write in lines and rules, seems plausible to me. It is the straitjacket of verbs that require an actor and a causal result. There is little room for the *conditions* of action, the context, the image that you cannot describe as an action. However, precisely that context is the object of spatial *design*. That does not mean, of course, that this limited way of thinking has not yielded impressive results from the Old Greeks onward. The invention of writing is in that light an unrivaled human achievement and a revolution, but through its success it has obstructed other parts of our imagination.

Surviving ideas

A predecesor of that belief is, that human spirits being freed from a body by death, can stay alife as good or evil spirits. An agricultural ('neolithic') variant is, that unconciously sleeping ideas are passed on to future generations as seed, once awakening somewhere if they fall in good soil.

Failing mortals then can at least gain comfort and hope from their descendants. In their turn, these are loaded with expectations and written prophecies of their ancestors.

§ 44 CULTURE SELECTS IDENTITY AT LEVELS OF SCALE AND TIME

CULTURE HAS DIFFERENT MEANINGS ON DIFFERENT LEVELS OF SCALE

You cannot compare family cultures with a national culture.
You can check to what extent they are part of it and derive conditions from it.
A family counts on a national defense, legal protection and a technical infrastructure on a larger scale. An urban culture supposes a commercial-industrial culture *including* nurturing rural cultures.

CULTURE FLUCTUATES BETWEEN TRADITIONAL AND EXPERIMENTAL

The transfer of culture ('tradition') to a child stumbles after about 15 years on a natural resistance that partly reverses existing standards and makes generations[a] different.

This may result in a synchronous cultural wave with a period of about 15 years (especially with a baby boom or a large-scale migration).[b]
If the next puberty neutralizes the previous, the norms of the generation before those of the educators (grandparents or ancestors) may return.

The roughest extremes that can be distinguished in such a cultural phase change is a transition from 'traditional' to 'experimental' and vice versa (***Fig. 249***).

The administrative context layer that accompanies it, varies with changes of government between 'following' and 'driving'. Culture itself goes up and down with economic waves of growth and crisis. Economic decline brings war, migrations, birth waves and innovations, but also a rise of conservatism.

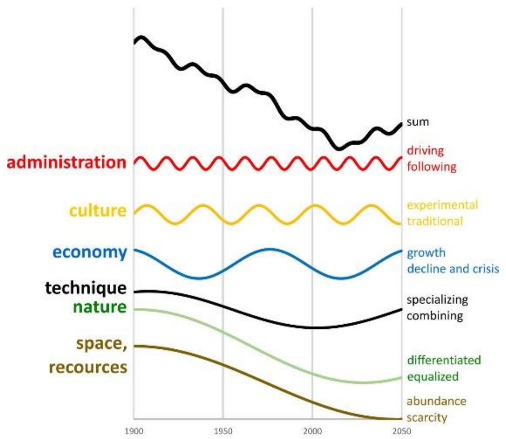


Fig. 249 Fluctuating context layers[c]

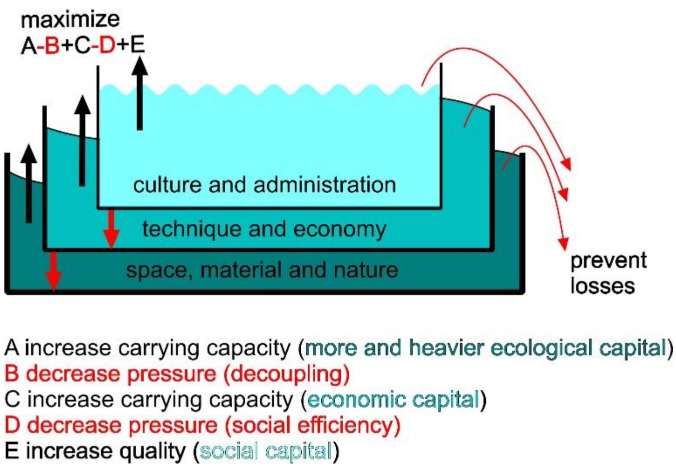
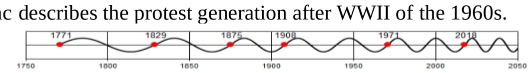


Fig. 250 Context: pressure and carrying capacity

The driving technique and the science that follows and produces it, has long periods of specialist innovations in the order of magnitude of a century (eg until 1960), followed by a period of diligent combination in commercial applications ('implementation') such as the iPhone. But one day one will have to return to the specializations in order

a Becker(1992)Generaties(Amsterdam)Meulenhof distinguishes for example generations born between 1910-1920, 1930-1940, 1940-1955, 1955-1970.
b Roszak(1968)The making of a counter culture(New York)Doubleday&Company Inc describes the protest generation after WWII of the 1960s.
c with variations such as the Schumpeter-Freeman-Perez paradigm for the economy: 

to be able to cope with the decline of nature from which one alienates and the exhaustion of raw materials.

The sum of all wave movements ('zeitgeist') moves and depends strongly on the influence (the amplitude) that you assume for each context layer.
As far as I am concerned, the technique, the technè, the design, is an underestimated driving force in history. Its influence is only surpassed by the decline of our abiotic and biotic basis (***Fig. 249***). ***Fig. 250*** symbolizes their finite carrying capacity under the pressure of shaky containers with increasingly lighter liquids.

CULTURE IS MOBILE AND VULNERABLE
The movement of ***Fig. 249*** is still a coarse simplification of the wave ridges that come rolling up from all directions. Crossing each other (interference) they form a chaotic moving landscape with changing images that mutually look different from each own position. Every culture is also vulnerable by the conditions bearing it (***Fig. 250***). Some forms of increasing scarcity can no longer be solved by technology.

Poverty is confronted daily with those conditions and their scarcity. It becomes out of the picture in a culture with growing prosperity. 'The technology has solved everything so far and it will also solve new problems.' The horizon of risks you oversee becomes smaller. Insurers are selling fear and you should not think of your car stopping on the highway without quick help, or that the wine will be up tonight.

Half of your income is spent on securing your future: army, police, a legal system, pension, health insurance, ensuring home and household defects.
The remaining saldo on the bank can be hacked or reduced due to a crisis.

For all that you have spent hours every day, building up the stress that undermines physical resistance for escape or fight, only allowed after working hours (compensated in holidays, sports or crime).

This culture-pessimistic image of an industrial-commercial society individualizes its members within their own hard-won and secured house with safe friends.

On another level of scale it is the call for walls around the own fort: 'own people first'. The newspaper selects what its readers want to read and readers in turn deny what they do not want to read. This way every period in history also selects its own history.

ART AND SCIENCE SHIFT BOUNDARIES OF IMAGINATION
Visual arts, poetry or music shift the boundaries of your imagination with images, words or sounds.[a] They not only bring about the enthusiasm[b] or even 'ek-stasis' ('ecstasy' p17), which we experience with 'beauty' (the swing of Aesthetic quality in ***Fig. 12*** p29), but also the ex-sistential (out-standing) experience by which you step out of the boring or chaotic daily life for a moment.

a A 'verbal definition' of 'art' does not show what it *is*, but what it *does*.
b 'Enthusiasm' is originally Greek for 'the god entering' and 'ecstasy' for 'step out', apparently out of yourself. They were probably both experienced in the Bacchus cult. The Latin equivalent for 'step out' (ex sistere), is literally the same, but probably has a very different emotional value, connected with 'birth' and 'existence'.

Since the invention of photography overloaded us with realistic images, we stepped aside to non-figuration through impressionism and expressionism.
That is also a form of withdrawal.

The poetry frees you from the boundaries of everyday linear language and shifts your imagination with metaphors connecting chaotic and rationally experiences, with or without rhythm and rhyme. Rhythm and measure (rap) creates a bridge to the music.

In music, recognition and surprise alternate as themes and variations (***Fig. 12*** p29). The compositions as a whole mutually vary between the rare extremes from monotone to chaotic, more or less restrained by rhythm and measure.

The *order* of sounds ('melody') settles remarkably easily in the memory, even if it fuses in fugues, or if the key changes.
This sensitivity to sequence indicates an important neural capacity, reminding to that of complex muscular action for any simple movement (dance).

These are parts of the artistic-religious *counterculture*, a counterweight to monotony or chaos in everyday routine of production and consumption.
Between boredom and overload fluctuate recognition and surprise.
Too much repetition demands surprise, too much differences demand recognition.

Such a fluctuation is also visible in the architectural heritage.
The turbulent, early Middle Ages full of uncertainty demanded strict, Romanesque architecture. The later Middle Ages brought more peace, wealth and boredom.
The reaction was a more flamboyant Gothic architecture.

The discovery of America opened a world full of uncertainties.
It meant a return to 'the ancients' with renaissance architecture.
Science then also wanted to 'know for sure'. When the pendulum moved again to carefree abundance, Baroque architecture counteracted its boredom. In the storm surge of the industrial revolution, it switched to familiar neoclassicism.

When the revolution had gone and the sciences self-confident, the art nouveau took its task to surprise. The world wars called for modernism, the peace for post-modernism.

On a much smaller scale one finds more differences, ornaments and colors in the interior of those who are doomed to annoying work than in the businesslike, 'nice tight', quiet interior of those who have a busy job.

There are also differences between old, young and very young. The cross, the Buddha statue and the pop idols recall the religious component in the artistic-religious counterculture.

The precise anatomical drawings of Leonardo da Vinci (***Fig. 251***) show the way in which artistic imagination can shift boundaries in a scientific representation.

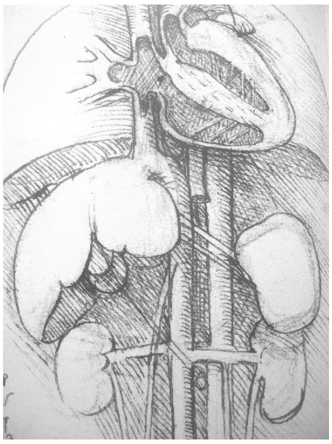


***Fig. 251 Leonardo da Vinci's drawing of the heart in 1509*[a]**

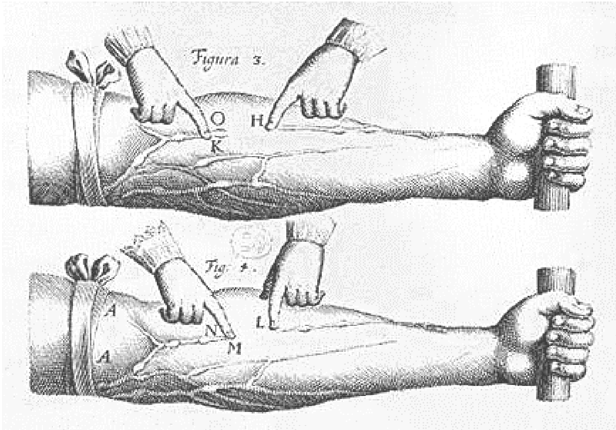


***Fig. 252 Proof of blood circulation through Harvey in 1628*[b]**

Leonardo and Vesalius first had to observe carefully and to draw the anatomy before Harvey (***Fig. 252***) could imagine a circulatory system and then prove how it works.

Every language, counting, cooking, administration, governance, education, mathematical formula, scientific research, scientific experiment, report, construction of an argument, telling a story, reconstructing history, requires a strict *sequence* of actions, words, numbers or operations (eg cooking according to a recipe),.

a Zöllner(2016)Leonardo da Vinci(Keulen)Taschen p446-448

b Harvey(1628)Exercitatio Anatomica de Motu Cordis et Sanguinis in Animalibus(Springfield1928)Thomas p100-101 https://ia902704.us.archive.org/12/items/exercitatioanato00harv/exercitatioanato00harv.pdf

§ 45 CULTURE SUPPOSES A DESIGN

Fig. 7 p24 distinguishes modalities, levels of scale, context layers and object layers of design. Culture then exhibits the following design features.

Modality ⇓ ((true⇒probable⇒possible⇒imaginable)∧desirable)
Norms and values refer to the goods and behaviour **desired**, shared and transferred by former generations. These are limited by their **imagination**, **possibilities** and **expectations** supposed to be **probable** or even **true**.

Culture, however, is redesigned by new generations with new possibilities.
These possibilities change by technical inventions once designed with extended imagination. They change the old desires, imagination, skills and expectations.
The possibilities, however, do not only increase.

They decrease by overpopulation and depletion of raw materials.
Until shortly, the abiotic and biotic conditions of culture have been tacitly supposed. Reassured by religion or the apparent power of technology, they were self evident.
The increasing knowledge, however, made us aware of them as the material conditions of any culture. That conciousness became a new element of culture itself.

Levels of scale ⇓ (…,10m,3m,1m,…)
Identity and group identity are scale sensitive, and so are the cultures with which you may identify yourself. Your life style, your family at home, your school, your working environment, your vacations, your village, city, football club, region, nation or continent all contribute to your identity.

Identity is two sided: the inner side is your self-image, the self-image of your family, school and so on. The outer side is the image the others may have from you, your family, your school and so on. Speaking *about* these identities is looking from the outside, calling them 'culture' or 'subculture'.

Context layers ⇓ (Abiotics ⇑ Biotics ⇑ Technique ⇑ Economy ⇑ Culture ⇑ Governance)
If culture is defined as 'set of shared suppositions and material conditions' (supposing economy, technique, and a conciousness of (a)biotics), then putting culture in a context that seems part of itself, may be paradoxical. That paradox is solved by scale articulation. A subculture may function in the context of a larger culture.

So, speaking about the 'context of a culture' here implies speaking about a subculture. For example, political parties in a national democratic **government**, are subcultures. Their suppositions may conflict with each other and with those of the national culture. Their intention is to change that context into their own design of national culture.

In fact, we all take part in **subcultures**, different from a larger cultural context.
A club has its own regulations and habits. These do not have to be in conflict with that larger context, but if so, their adaptation requires a (well understood and accepted) superculture of compromise (democracy), otherwise subcultures will radicalize.

The context of **economy** confronts any subculture with the measure of dependence on exchange at a larger scale (mondial, national, local). That plays political parties apart. Complete self-sufficiency of a small community supposes (a)biotic and technical limits of large scale mining, harvesting and production (economies of scale).

A community may require a territory of ca 5 000m^2/person for food production only. The production of goods and services in general, require larger territories, dependent on the applied **techniques** (materials). The worldwide habitable land per person is currently shrinking below 10 000m^2/person, due to population growth. Nature pays.

Allow me some 'culture criticism'.

The reaction of **biotics** on overpopulation of a species in high density, is spreading epidemics and war. Your cherished right to get children tacitly neglects *their* future. Birth control is a taboo in many cultures, digging their grave. The consequences of the dramatic decline in biodiversity remain out of sight in your cherished lifestyle *now*.

The **abiotic** context provides an abundance of energy that could enable survival.
The sun delivers nearly 1 400watt/m^2 on the Earth's cross section. About 30% is reflected, 21% is converted into heat in the watercycle, and 2% into wind.
The remaining 47% is ca 5 000 times the energy used by humans *and* the biosphere.

We, however, do not use it. We use the fossile remains of biotics, a little of wind and sun, but 99.9% is directly converted into heat and radiated back to the universe. Economical interests concentrate on wind, but in my country then needs 5 times its surface to cover our energy requirement. By photocells, that would be 1/5.

The shared suppositions of culture are not sufficient to survive without a more encompassing consciousness of its shared material conditions. The urban separation from that (a)biotic context turned the awareness into indifference.

Object layers ⇓ (Content ⇑ Form ⇑ Structure ⇑ Function ⇑ Intention)
The **contents** of culture are its suppositions and material conditions. These are dispersed (shared) in a heterogeneous **form** by words, images, and tacit signs.
That form (spreading) is maintained by a **structure** of connections and separations.
The **function** is cooperation, the **intention** is survival.

In a community, the connections and separations (structure) within and between classes, ages, professions, and so on, maintain a clustered form of subcultures with a cultural consciousness that ranges from high to indifference. Fake news disrupts the connections, hardens the separations, and undermines function and intention.

CULTURE CAN BE CONSTITUTED

Is culture constitutable according to ***Fig. 13*** on p37? It reads:

A	difference	⥣ change	⥣ coherence	⥣ selection	⥣ combination	⥣
B	metabolism	⥣ regulation	⥣ organization	⥣ specialization	⥣ reproduction	⥣
C	information	⥣ security	⥣ affection	⥣ identity	⥣ influence	

People differ. Without that difference, culture would be reduced to competition. Nobody would be encouraged to take on special tasks (based on a unique identity). As by equally programmed cloned robots, collaboration would only increase quantity. Culture would be reduced to a struggle for life, each for itself.

Difference, however, enables imagining **change**.
Difference of change (*stability* steering active changes) enables **coherence** (structure).
Selecting such structures enables to **combine** them (production).

Different combinations enable **metabolism** (economy).
Change of metabolism enables regulation (jurisdiction).
Coherence of regulation enables **organization** (management).
Selecting organizations enables **specialization** (cooperation).
Combining specializations enables **reproduction** (education).

The concept of reproduction enables sharing it as **information**, **securing** it for cooperation, education, and for next generations. Organized security enables trust, **affection** for the cultural heritage obtained. It enables cultural **identities**, recognized by others, getting an appreciated role in the community, **influence**.

11. DESIGN CHANGES CULTURE

§ 46 CONCEPTUAL CONDITIONS PRECEDE DESIGN AND SCIENCE

THE INTENTION OF DESIGN IS DIFFERENCE AND CHANGE

Your imagination is enriched *and* limited by suppositions (including images).
These are selected and transferred by the prevailing culture and language.
If unnoticed, these act as compelling truths and probabilities.

You may become rich and content obeying these conventions, but a designer should explore the space *beyond* the probable, exploring the limits of what is possible.
Hertzberger's 'Avoid clichés, collect images, put them in a different context and adjust them'[a] is the shortest and most concrete recommendation for designers I know.

Existing categories, generalizations and clichés may block imagination. Words *are* clichés. Poetry evokes new images, putting them in an unusual context or sequence.[b]
That is combinatorics, and a first step to make a difference in their meaning.

Images differ more than words, but advertisement images prove that images also may be not more than variants of clichés ('the happy family', 'the highest quality for the lowest price', 'ultimate enjoyment'). They leave little room to make a difference.
The possible then is limited to a compelling desirability looking as a probability.
Imagination is narrowed down to (false) alternatives with little difference.

Designing makes a difference and a change. A design is not more of the same.
What you cannot speak about, you should *not* be silent about. If language fails, you should draw. Try to imagine the incomparable. Do not immediately reject unlikely representations. What seems impossible, may be realizable under other conditions.

Design also these other conditions. Change the context, the direction of view.
Replace restrictive conditions by productive ones, in order to *make* possible.
Choose only restrictive conditions to stay realistic within what is possible.

In a manner of speaking, you may develop explosives expanding the space of imagination, but possibilities suddenly appearing in one direction require to concentrate on that direction, like a cannon closes other directions for expansion.
You may alternate expansion and compression breathing possibilities in and out.
The amplitude and frequency of that alternation are different for each designer

In the previous chapters, I critically explored some conceptual, Abiotic, Biotic fields of science. I did it, however, with the supposed conceptual abilities learned as a child (Chapter 3 p48). *Knowing* ABC then is... cABC .... That first c of individual understanding is a condition for the second C ('*shared* suppositions and conditions').
The next paragraphs study them in some relevant details.
All of them (cABC) seem to restrict our imagination to actual reality, but they also show vistas still beyond usual human imagination.

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a Hertzberger(1999)De ruimte van de architect: lessen in architectuur 2(Rotterdam)010 Publishers; Hertzberger(1999)Space and the architect: lessons in architecture 2(Rotterdam)010 Publishers; Hertzberger(2002)Creating space of thought in: Jong;Voordt; eds (2002) Ways to study and research urban, architectural and technical design (Delft) DUP Science chapter 42, p 389

b Jong(2012)Diversifying environments through design(Delft)TUD thesis p282

DIRECTION SUPPOSES DIFFERENCE

A subject as an observer supposes a view direction (frontal), and a focus point.
It can observe *differences* in any direction in the plane ⊥ that direction (lateral).
Even without observation (in an imagined image) you suppose directions.
The direction determines the difference you see (***Fig. 5*** p17)

The senses are able to distinguish directions (p54) before they are made conscious. Are *directions* then supposed in (a practical condition for) any observation of difference? Is 'direction' then a subjective 'a priori' *preceding* any difference?

An indivisibly small, directionless object (the 'point' in ***Fig. 58*** p125, in fact a 'location') differs from its environment itself in 'any direction'. This proves that 'difference' *can* be presented without any previous *idea* of direction. So, difference is conceivable 'without direction' or, if that amounts to the same thing, 'in any direction'.

In analytical geometry, 'direction' is itself a difference with respect to some other direction ('angle'), for example with respect to a direction of some coordinate system (p132). Direction then supposes a difference (of direction).
The plural form of two direction**s** already supposes difference.

Perhaps linear language misleads us. Different expressions in our language hide different practical conditions between difference and direction:

Expression	**Supposition**[a]
1 'the difference in this direction';	difference supposes a direction;
2 'the direction of this difference';	direction supposes difference;
3 'difference of direction';	direction supposes difference;
4 'different from direction';	direction supposes difference;
5 'X differs from Y';	direction does not seem to play a role.

Fig. 253 Hidden suppositions of difference and direction in linear language

With expression 1 you point to a direction to make someone aware of a difference.
With expression 2 you point to a difference, to make someone aware of a direction.
With expression 3 you specify direction as a certain *kind* of difference.
With expression 4 you observe different directions, eg between two straight lines.
With expression 5 you only distinguish X from Y; direction seems to play no role.

ANY OBJECT SUPPOSES DIFFERENCE

I assume that difference enables imagining a direction. Difference⇑direction.
The conceptual conditions 'c' in cABC (p39), precede any understanding of ABC.
According to chapter 3, anybody should have learned as a child at least to distinguish object, sequence, size, distance, place and quality ('c').

a The prepositions 'of', 'with', 'from', 'in' also have various suppositions that must be apparent from the context (difference of, different from). The common logic clarifies the use of conjunctions. There should also be a 'logic' of prepositions that can, for example, solve the ambiguity of the word 'of'. This seems a nice task for real linguists. Here, I concentrate only on difference and direction.

In chapter 3 p48 I argued that the concepts of object, sequence, size, distance, place and quality may develop succesively as a co-action with a primary human experience of 'movement→difference→direction' (not yet distinguished in these components). If 'movement' is the common physical foundation of action and co-action, then the conceptual conditions would have a simple abiotic basis.

Adding 'difference' and 'direction', cABC (p39) then reads:
difference⇑direction⇑object⇑sequence⇑size⇑distance⇑place⇑quality⇑A⇑B⇑C.
A, B and C are elaborated in ***Fig. 13*** p37 as a hypothesis, verified in several fields. 'Designing', however, supposes you can make *objects* not seen before, *beyond* ABC.

A *definition* of 'object' is difficult to give without becoming complex and circular. For example: 'an object *is*: upon which a subject can focus its attention, able to perceive, represent, display, describe, design or make it'. That is circular, because every used noun or verb (subject, focus, attention and so on) is itself an object.

A *constitution*, a sequence of *conditions* with which an object is only *possible* or *imaginable*, is simpler, but not easier.

For example: 'an object *supposes* difference in all directions' (***Fig. 5*** p17).[a]
The magic word 'difference' avoids the complex psychology of an attentive subject as an observer for the time being, but still then some suppositions remain: 'an', 'supposes', 'in all directions' and perhaps tacitly 'from one point'.

Indivisible points as objects can only differ by location.
That difference (distance) is a minimal condition for determining a 'direction'.
Without a second point, you cannot imagine a direction (***Fig. 58*** p125).

In order to constitute the concept of 'direction' from 'difference', you should first suppose a 'point' and its plural (at least a second, *different* point).
Then you still have to find a way to release an abstract concept of 'direction' from it.

The use of language already supposes a direction in time.
So, you may assume, that a second point is already enabled in every subject-verb-object representation. 'Subject-verb-object' hides 'viewpoint–addressed point'.
You cannot communicate without a supposed direction (viewpoint→addressed point).

Conceptual conditions are subjective, even if they *seem* to be shared by everyone.
How they are constituted from impressions can be different for each subject.
So, you can only assume that they *can* be constituted in a inescapable sequence, but it develops differently in everyone with detours and superfluous intermediate steps.

I assume, that a *minimal* conditional sequence remains reconstructable, even without assuming a learned successive build up in the human brain beforehand (a priori).
I assume, that that sequence can be transferred 'invariant' (p132) into another subject for every description or assertion with a 'viewpoint'.

---

a 'Context' then assumes 'difference of an object', ie 'non-object'. The negation 'not' is therefore immediately available as a third object (p15).

§ 47 CONDITIONAL ANALYSIS REVEALS HIDDEN SUPPOSITIONS

DIFFERENCE TACITLY EXTENDS ANY CONCEPT

Separated from a direct experience (p185), 'movement' can only be presented as 'difference of movement' (abbreviated as 'Δmovement').

Any concept, however, could be reconstructed as a difference: 'Δdifference', 'Δdirection', 'Δobject', 'Δsequence', 'Δsize', 'Δdistance', 'Δplace' and 'Δquality'. Difference enables to present these objects in plural or in a fourth dimension (a seventh direction) as 'change' (a special kind of difference).

The multitude of the plural form, forces to divide subjective attention' (focus) alternating between different objects, but not all of them in the same time.
You always observe 'case by case', 'from case to case', before you define an object that attracts your attention.

If a 'case' supposes an object *with* its context, then you belong to that context yourself, but you also place yourself as an observer outside the frame that you perceive.

That paradox is solved by the fact that your perception is perpendicular to the flat scene that you perceive.
The term 'context' then must be distinguished in the 2D image you perceive, and a 3D context that you construct in order to be able to involve yourself as an observer.

A subject constructs a summarizing representation (synthesis) of two objects in one third *concept* (p31), and then handle that third concept (set) as one object between other objects again in a summarizing representation, constructing ever larger sets.

Even without that construction, attention on itself requires 'difference'.
Difference in direction then enables difference in attention.
Attention 'concentrates' to a point (focus) without losing sight of 'the rest' ('frame').

'Supposes' or 'becomes imaginable with a prior representation of' I gave the symbol ⇓. 'Supposed by', 'makes a representation possible of' or 'enables' I gave the symbol ⇑. Different X, I will abbreviate as ΔX (not immediately supposing quantity).

The 'conditional *synthesis*' so far, then reads:
Δdifference⇑Δdirection⇑object⇑Δsequence⇑Δsize⇑Δdistance⇑Δplace⇑Δquality.
The differences raise the question which differences are included in our truth based *knowledge*, but the designer should ask which differences are *possible* (can change).

WORDS ONLY PARTLY COVER NEW POSSIBILITIES

This chapter translates impressions, images in a sequence of generalizing words.
I will repeat some of the foregoing with an additional constitution of some details.

The words rarely fully cover the images that fit in the constitution. I only can hope that these words in the context of their linear sequence will still evoke the intended image. Images are multi-dimensional. They do not always comply with the linear truth logic with its prohibition of linear contradictions (***Fig. 5*** p17 and § 21 p105).

I will not check the suppositions of all used words, if they are not substantial (trivial[a]). That would, after all, amount to the constitution of our entire vocabulary.
Because they are widely shared, I only constitute some of the most substantial.

If I use words for substantial suppositions that are not, or not yet, constituted, then these are marked with an asterix (*). Where they are earlier constituted, they are **bold**. Where they appear for the first time, they are enclosed in quotation marks '**bold**'.

An asterix (*) means substantial, but 'not (yet) constituted'; **bold** means 'constituted'; '**bold**' means 'constituted for the first time'.

In the chapters 8, 9 and 10, the Abiotic, Biotic and Cultural conditions still claimed to be 'objective' (without assuming a subject). In order to *describe* them, however, I still need the language that subjects may share with each other.

A CONSTITUTION BRANCHES AFTER THE CONCEPT OF 'OBJECT'

Fig. 254 p284 combines the conditional sequences of the previous chapters.
Some intermediate steps are added.
These may appear if you reason back in a reverse sequence ⇓ ('conditional *analysis*').

For example: **∆difference⇑∆direction⇑object** may be expanded by a more detailed analysis: **object⇓∆'in any direction'⇓∆direction⇓direction⇓∆point⇓'focus point'⇓difference**.
So, **∆difference⇑focus point⇑∆point⇑direction⇑∆direction⇑∆in any direction⇑object⇑** …
is a more complete conditional *synthesis*.

∆object raises the typical design question 'how to proceed now?'. It should enable more than geometrical objects requiring **∆sequence⇑∆size⇑∆distance⇑∆place⇑∆quality**.

Besides the object, there is still a 'rest' in the image, a '***context***'.
That enables imagining an **object** in different **contexts** (Hertzbergers advise on p279).
The very **difference** *between* **object** and **context**, is their '**boundary**'.

Deviating from that **boundary** inwards into the **object** means '**denial**' of the **context** ('**confirming**' the **object**), and outwards denial of the **object** (**confirming** the **context**).[b] The logical operator 'and' ∧ (***Fig.*** 49 p106) covers the **boundary** in between. 'Or' ∨ covers both object and context ('**frame**').

Frame covers *both* '**object∨context**'; '**object∧context**' covers the **boundary** *between*.

You now may continue with a second branch: **∆object⇑context⇑∆frame⇑'grain'**
or a third branche: **∆object⇑context⇑∆boundary⇑∆denial⇑∆confirmation⇑observation**.
Branching downwards would mean, that the same object is imaginable by different suppositions. ***Fig. 254*** shows only one stem in order to prove the possibility.

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a I rely on a common interpretation of 'trivial' words such as 'one', 'the' and the concepts I have circumvented with symbols such as logical operators.
b Confirmation supposes denial, not vice versa. After all, denying your denial is a confirmation, but confirming confirmation is not a denial.
At the 'inside' of the boundary you can 'question' the object ('What is that?'), at the outside you can question the context.
By doing so, you change the level of scale through detailing or expanding your view.
For an observer it concerns impressions, for a designer expressions (constructions). In both cases confirmation ⇓ repetition.

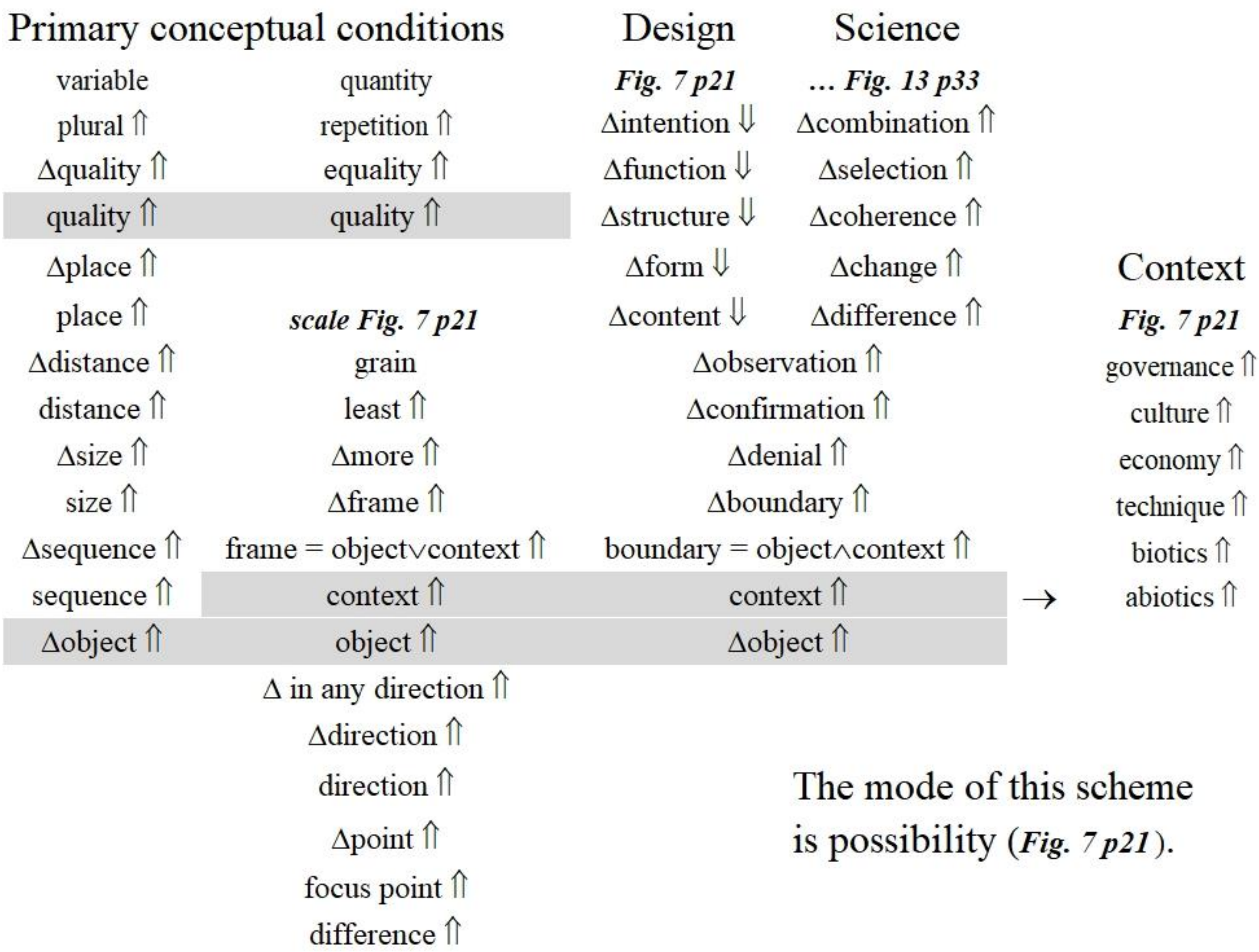

Fig. 254 A constitution tree of conceptual, design, science and context conditions

Fig. 254 summarizes the suppositions assumed to be constituted until now: **abiotics, affection, biotics, boundary, change, coherence, confirmation, content, context, culture, denial, difference, direction, distance, economy, equality, focus point, form, frame, function, governance, grain, identity, in any direction, information, intention, least, metabolism, more, object, observation, organization, place, plural, point, quality, quantity, regulation, repetition, reproduction, security, selection, sequence, size, specialization, structure, technique, variable.**

Object∨**context** enables to make a summary of both as a new concept (**frame**).
Different **frame** (per **place** or moment*) enables to imagine '**more**'.
'**Least**' differs from **more**: **Δobject⥣Δcontext⥣Δobject∨context⥣Δmore⥣least**[a]
(the second branch). **Least** may provide this supposition in ***Fig. 58*** on p125.

Balancing at the **boundary** may be called 'questioning'.
Design and science require some **denial** of actual truth.
Observation enables design and science.
Design starts with an empty **object** in a given, changing or even uncertain **context**.

a This constitution of 'least' may be doubtful, and still open for improvement.

DESIGN SUPPOSES MAKING A DIFFERENCE

Designing is 'making difference' (adding a Δ), creating a new step up in ***Fig. 254***. Δobject makes new objects imaginable. These may have already a name, but you can continue with new imaginable possibilities still without a name, by design.
If the suppositions for that new step have been made by others, transferred to us in the prevailing culture and language, then you would call it 'learning'.

Within the subject, however, learning also requires its own creative co-action (make a distinction, not a copy). For example, in order to enable an understanding of '**direction**', '**focus**' must be alternated ('looking around') into **different** attention points.

Designing and learning are cyclical. The staircase is repeatedly incurred per 'case'.
A conditionally passed concept then is available on every next or previous step.
As a result, the concepts or images undergo continually small changes ('nuances') that do not come back in their labels of well-defined, but generalizing words.

What is constituted this way is not a 'semantic network' that associates or *defines* concepts, but a network that makes new concepts *possible*, using concepts that have ever passed before in any branch: downward eg **Δdifference⇓difference**, horizontal eg **least⇓distance**, and even upward eg **Δsize⇓Δquality** (scale paradox) in ***Fig. 254***.[a]

In that case I put these crosslinks to earlier passed suppositions ('couterconditionals') between brackets eg (**Δsize⇓Δquality**)⇑**Δobservation**.

Constitution allows to skip steps and still keep the conditionality of the beginning and end result ('*contraction*'), for example **difference⇑observation**[b]. This 'transitivity' is obvious, but in ***Fig. 254*** several intermediate steps unveil tacit suppositions required to arrive at **observation**. ***Fig. 7*** p24 and ***Fig. 13*** p37 are also contractions.

Constitution aims to clarify the unspoken suppositions, to insert steps that can lead to new representations and lateral branches if you add Δ. So I take the contraction of ***Fig. 13*** p37 as a starting point to test, complete it with forgotten steps and explore potential side branches ('*expansion*'). This, for example concerns the representations that have enabled the language of science (ABC of chapter 7-10) *and* design (***Fig. 7*** p24).

Fig. 254 only *illustrates* the role of practical conditionality in our imagination.
The reality may be more varied and complex, to be supplemented by further inquiry.
For example, in ***Fig. 254*** lacks distinctions between 'difference between', 'difference from', 'difference of', and 'difference of a'. These may have to be distinguished.
For the time being, these distinctions have been bypassed with a symbol Δ.

In the practice of designing and executing, the conditionality is recognizable in any step-by-step *plan* with an irreversible sequence of steps.[c]

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a This is reminiscent of a learning artificial neural network (§ 29 p162), but designing requires also new axons growing between the neurons.
b Observation supposes (⇓) difference. If everything would be white, then nothing could be observed.
c Eekhout(2015)Componentontwerpen en productontwikkeling(Amsterdam)IOS Press

The 'ingenious inspiration' must also consist of such steps: making **connections** fast and setting up steps towards an innovative design concept.
If these steps could be followed and described in slow motion, some understanding of them could make the design practice more innovative.

The subject-bound, subjective conceptual conditions for conceivability and design still require discussion and study, given the variety of design methods.

These conditions are, however, necessarily described from the view of such a subject and in its linear language. The sentences of that language then contain (unlike images) an active operating subject x as an actor, a verb and a passively changing object y. You may display that as y(x), be it in the sense of a potentialis[a].

a Potentialis is actually a subjuctive mood, https://en.wikipedia.org/wiki/Subjunctive_mood : 'a verb-mode that is common in, among others, the Indo-European languages. A grammatical form of comparable meaning is also known in the Semitic and Finnish-Ugric languages.' If the potentialis only exists in a few languages, then that could be an explanation for an innovative advantage of the speakers with these languages as their mother tongue. After all, they are used to thinking in terms of just that language.

§ 48 DIFFERENT DIFFERENCES (VARIABLES) ENABLE PHYSICS

In § 36 (p208) an advance has been made in response to some examples from physics. This paragraph explores some of its conceptual suppositions in detail.
Physics assumes a linear truth logic without contradictions (chapter 6 p103) and a mathematics of exact **equality** and **repetition** (chapter 7 p123).

Putting it in the mode of possibility does not replace, but *includes* physics.
It takes physics as an impressive design. Its beautiful architecture, the choice of its materials, variables (**content**), arranging (**form**), separating and connecting them (**structure**), determining the external workings of this strong building as a whole and those of its parts (**function**) has served many **intentions**.

Creating its **content** has been the first act of design: unexpected distinction.
Newton's distinction of mass* m, **distance** s, time* t and their relativity enabled a different **coherent** design of mechanics.

The distinction of volume* V, pressure* P and temperature* T, enabled **cohesion** on the level of large numbers of particles (thermodynamics) and handling the uncertainty on the smallest imaginable scale (quantum physics).

Different **intentions** motivated the construction of this building.
Mathematical reasoning started with the long experience of hunting and collecting.
Collecting supposes **selection** and **combination**, thinking in sets.
Hunting involves not only the manual dissecting (**selection** and **combination**) of the prey, but also the *distribution** of the booty.

Agriculture taught a **separation** of space*, a division* of the time* in **equal** seasons, months and days, to **quantify** and discretely *distribute** them over the year.
Trade taught to **quantify** goods (to name **equal** *parts**), to detach this number* from the **quality**, the value*, to multiply (**combine**), *divide** and exchange goods.

How to fill the gaps, their tacit suppositions? This exercise selects only some of them.

VARIABLES CAN BE CONSTITUTED

Change supposes a special kind of **difference** in the **direction** of time*.[a]
Any **change** can **change** more, but not always less. If you can no longer observe or imagine less, then you *approach* the limit of **change**: **Δchange**⇑'**duration**'.

So, **duration** supposes a **quantity**⇓**change**[b]. The (**change**⇓**least)**⇑'**moment**'. Different moments make time* imaginable: Δ**moment**⇑'**time**'. In the same way: Δ**point**⇑space.

Both limited to one **direction**, **space** s and **time** t, enable Δs and Δt **(distance** and **duration)**. **Coherence** of both requires a third object in the image (p31).

a Ashby(1957)An Introduction to Cybernetics(London)Chapman p9
b I use ⇓ as a specification: quantity⇓change ('quantity supposing change') specifies the quantity as 'quantity concerning change' or even 'quantity of change'. That way I can distinguish 'quantity of mass' as quantity⇓mass, or in the next sentence 'least of change' as least⇓change.

For example, velocity* v=Δs/Δt is a **coherence** of **distance** and **duration**: (**distance**⇓**duration**)⇑'**velocity**'[a] and (Δ**velocity**⇓**duration**) ⇑'**acceleration**'.

Different directions, make more **variables** conceivable than **distance** and **duration**: (Δ**directions**⇓⊥⇓Δ**distance**)⇑'**surface**' and (**surface**⇓⊥⇓Δ**distance**)⇑'**volume**'.

COHERENCE LIMITS THE POSSIBILITIES OF CHANGE AND MOVEMENT*[b]
The mathematical operations* between **selected variables** may be constituted as **combinations**, supposing repetition*(chapter 7).
Formulas with operations* such as force*=mass****acceleration** suppose a **coherence**, enabling force*/**acceleration** = mass*, but force *on*, and acceleration *of* mass.

I cannot imagine force* (or acceleration) without a mass*. The reverse I can.
So, force*⇓mass*, but I doubt. Before Newton, their combination has been experienced as 'weight', expressible in pounds. Force* was still an attribute of mass ('impetus'), transferable on another mass causing '**movement**'⇓Δ**place** or '**deformation**'⇓Δ**form.**

Newton's distinction of force*, mass* and **acceleration** enabled their **coherence** as a *design* with its object layers of ***Fig. 7*** p24 **structure**⇓**form**⇓**content**. If '**mass**'⇓**content**, then it enables **form**, a 'state of dispersion'⇓(dispersion*∧accumulation*).
Coherence reminds of **structure**, a set of separations* and connections* (p27).

Dispersion* and accumulation* can constitute entropy* (***Fig. 173***, p194) and force*.

Fig. 255 shows **(more⇓distance⇓objects)⇑'dispersion'.** You can always imagine **more dispersion**, but not always less**:** (**dispersion**⇓**least**)⇑'**accumulation**'.[c]

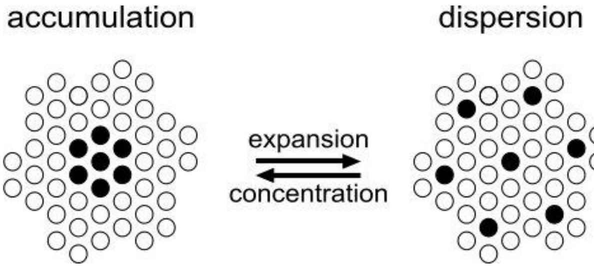

Fig. 255 Accumulation and dispersion

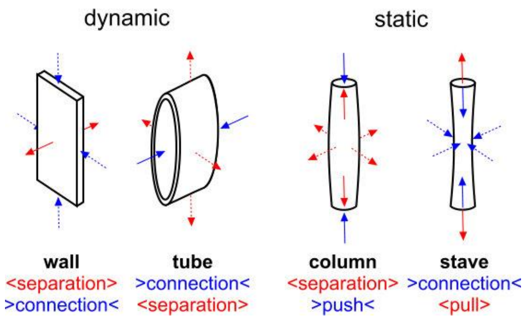

Fig. 256 Separation and connection

Fig. 256 shows how **accumulation⊥dispersion** of immobile* (solid) **mass** limits the freedom* of **movement** by separation*⊥connection* (see also ***Fig. 10*** p28).
Wall* and tube* are substantial in dynamic, column* and stave* in static mechanics.

Verbal descriptions of these more dimensional concepts are possible, but complicated. ***Fig. 255*** and ***Fig. 256*** may speak for themselves as a visual constitution of '**accumulation**', '**column**', '**concentration**', '**connection**', '**dispersion**', '**expansion**',

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a If you would take actual *velocity* as a supposition, then the usual coherence v⇓s*t might change into t⇓s*v.
b Examples. In a cylinder motor, the cylinder limits the expansion of the expanding gas into one direction (***Fig. 172*** p90).
The 'degrees of freedom' of individual molecules (the freedom of movement in every direction and rotation) are limited by the fixed cup shape (***Fig. 10*** p13). In a laser (p96) the random movements of photons are limited into one direction.
c The meaning is scale sensitive (grain p28215).

'**pull**', '**push**', '**separation**', '**stave**', '**tube**', and '**wall**'.
So, I will not constitute them further verbally.

So, (**Δplace**⇓**Δtime**)⇑**Δmovement**⇑**acceleration**. Force*, resistance* and mass* can be constituted as (**push**∧**pull**)⇑**'force'**⇑**acceleration**⇑(**'resistance'**⇓**'mass'**).

Immobile* **objects** in a structure* limit the **movement** of mobile*[a] **objects (Fig. 257).**
So, Δ**separation**⇑(**separations**∧**connections**)⇑**structure**⇑**coherence**⇑Δ**movement.**

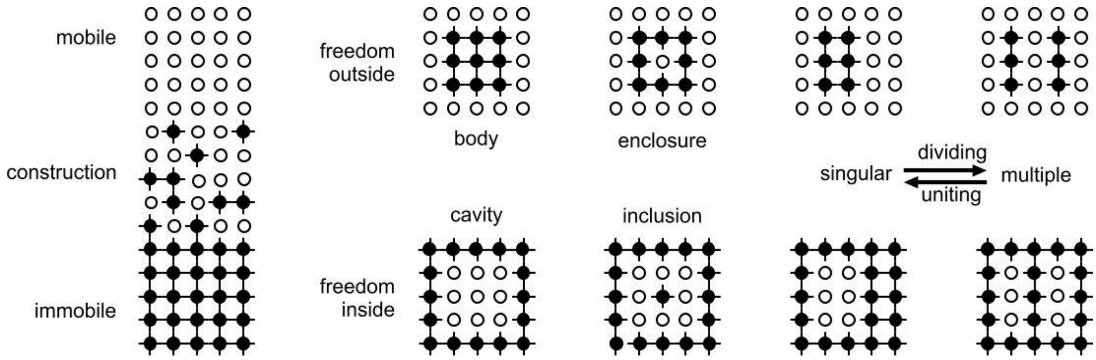

Fig. 257 Examples of coherence, sets of separations and connections

The upper row of ***Fig. 257*** (freedom*⇓outside*) shows an improbable* enclosure*⇑(freedom*⇓inside*)[b], elaborated as counter-variants in the lower row.
Biotics mainly suppose cells, fixed enclosures* of mobile* **objects**.

Fig. 257 may speak for itself as visual constitution of '**body**', '**cavity**', '**construction**', '**dividing**', '**enclosure**', '**freedom**', '**immobile**', '**inclusion**', '**inside**', '**mobile**', '**multiple**', '**outside**', '**singular**', '**uniting**'. I will not verbally constitute them further.

Pressure*, energy*, temperature*, heat* and entropy* then can be constituted.
A subjective in-pression on your body is already a pressure*, a **force** on a **surface**:
(**force**⇓**surface**)⇑'**pressure**'; (**pressure**⇓**volume**)⇑(**Force**⇓**distance**)⇑'**energy**';
(**quantity**⇓Δ**size**⇓Δ**object**)⇑'**average**'; (**average**⇓**energy**⇓Δ**movement**)⇑'**temperature**';
(**energy**⇓Δ**temperature**)⇑'**heat**'; (Δ**heat**⇓**temperature**)⇑'**entropy**'.

DIFFERENT SELECTIONS ENABLE DIFFERENT COMBINATIONS

Chemistry[c] and nuclear physics concerns **separation** and **connection** of small particles.
Separating usually costs **energy**. **Connecting** generally provides the **energy** released when **concentrating** particles give up their **freedom** of **movement**.
Molecules suppose atoms connected by **pull**, separated by **push** at shorter distance.

Molecules increasing in more than one dimension, however, increase **push**⊥**pull**.
Separation then may release the **energy** from those 'compressed springs'.
Something similar applies in the atomic nuclei, so **separation** of large nuclei or **connection** of small, both can detach nuclear **energy** (fission or fusion).

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a 'Mobile' is supposed in the aggregation states of liquid and gas, waves and individual particles with all 'degrees of freedom'.
b Jules Deelder once said this beautifully: "Within the limits, the possibilities are as great as outside".
c In Dutch 'chemistry' is called 'scheikunde', the art of *separation*.

Mechanics and thermodynamics, suppose a smaller variety of **objects** (**∆object** in ***Fig. 254*** p284). The sketch of their constitution then remained simple.
In chemistry and nuclear physics, however, more **forces**, particles and **combinations** have to be distinguished.

Moreover, the coherence in chemical compounds changes per environment, and (even with the same combination of elements) may have a different **form** and thereby a different operation* ('isomers' ***Fig. 210-Fig. 213*** p233).
The next paragraphs therefore go in less detail than done here for physics.

§ 49 DIFFERENT COMBINATIONS ENABLE BIOLOGY

BIOTICS LIMIT A COMBINATORIAL EXPLOSION

The combinatorial explosion of possible combinations is much greater than the small number that survived its selection in the course of evolution.
The 12 elements of § 37 p216 can be combined at most in 12^2 pairs.[a]
If the largest DNA molecule has 250 million base pairs[b] each consisting of 22 connections of 4 types (C, O, P, N), then there are $4^{5\,500\,000\,000}$ combinations possible.

However, DNA is limited to fixed combinations of C, O, P and N (base pairs), leaving $4^{250\,000\,000}$ possible combinations.
If there are 10 000 000 (10^7 or 4^{12}) species, each with their own unique DNA, then only a very small number of combinations (4^{12}) survived the evolutionary selection of the unimaginably large number of possibilities.[c] That number is even smaller when you consider that the DNA of most species counts less than 250 million base pairs.

Evolution, however, selected only 22 combinations of 3 base pairs out of 4^3=64, coding 22 types of amino acids. ***Fig. 192*** p223 shows an unreal example of a small protein molecule containing 20 different, most usual amino acids.
Life uses actually only 100 000 much larger proteins. These 'selected combinations' count 50 to 3 000 amino acids out of ample 22^{3000} possibilities.

In addition to that group of proteins, there are many other groups that are combined into *organs*. On a subsequent scale level these are combined again into organisms and again into organizations.

From 26 characters of the alphabet 26^2 words of 2 characters can be put together, 26^3 of 3 characters and so on. That is already 11 881 376 possible words from 5 characters. These are then only the possibilities in that one dimension of the linear language, but proteins branch mainly into two dimensions and organs into three. Language is then a combination of a limited selection of words that are moreover limited in a prescribed grammatical order. The vocabulary of biotics is larger.

Difference in selection makes combinations possible: Δselection⇑combination.
A selection of steel beams and concrete surfaces allows for combinations other than wooden beams and bricks. Life phenomena start with a small selection of materials, but that has produced an unimaginable number of combinations at every level of scale.

DIFFERENCE IN COMBINATION ENABLES METABOLISM

Chemical reactions enable metabolism. A combination of substances then is changed to a different combination. An organism combines such reactions in cycles (for example ***Fig. 206*** p231 or ***Fig. 227*** p240). Every chemical reaction, every reaction

a 'Combination' is not used here in the mathematical sense. An object then may only occur once in the selection from all (also selected) possibilities. An object may occur here more frequently and each different sequence is counted as a different possibility.
b https://en.wikipedia.org/wiki/DNA
c The pharmaceutical industry thinks to outwit 4.5 billion years of evolution by coming up with drugs that do not occur in nature. It is unlikely that evolution has not tried these chemical compounds already long ago. She then rejected them because they did not benefit the species in the long run due to their side effects.

cycle, every organ, every organism and every organization, in short every system* has an input* and an output* (⇓ inward and an outward movement of substances[a]).

'System'⇓**'input'**Δ**'output'** (difference between input and output), otherwise it is a tube (throughput). **InputΔoutput⇓Δcombination**. A system recombines, changes (makes different) combinations. Storage*⇓delayed*⇓**output**. This allows new inputs to be combined with old inputs. Death*⇓**output/input** (/ means logical without, see p106).

CHANGE IN METABOLISM ENABLES REGULATION

Catalysts, enzymes (bio-catalysts), RNA-recipes, hormones or (un)blocking stimuli outside the organism, **accelerate** or delay* reactions and the operation* of systems. For example, the search for food ⇓ an **accelerated selective input**, triggered by the hormone ghrelin.[b] This hormone is a small protein (peptide), quickly made with an RNA recipe (***Fig. 194*** p224). Its appearance by **entropy**-driven chance is improbable.

COHERENCE IN REGULATION ENABLES ORGANIZATION

The release of C from CO_2 is abiotically an improbable reaction.
It is **accelerated** by photosynthesis (p229).
The oxidation of hydrocarbon (incineration) is a probable and rapid (explosive) process that is delayed* by stepwise energy transfer (p218, p224).
Photosynthesis and slowly burning ⇓ is a cycle of improbable reactions, connected in a strictly conditional sequence, separated from more likely entropy driven processes.

Such a cycle of **acceleration** and deceleration* ⇓ a stable relationship in regulated processes (organization). Such cycles appear everywhere within a living organism. Their abiotic probability (**entropy**) **outside**, is nearly zero.
Each reaction provides input for the next, but such a cycle as a whole (at another level of scale) also has entries and exits for **selective input** and **output**.

This **selection** of import and export ⇓ **regulation** and also **separation** of more likely processes (***Fig. 197*** p225). Membranes select as sieves or they are equipped with selective valves or devices (***Fig. 205*** p230). The output of a cycle works again as input from another cycle elsewhere. This ⇓ a connecting infrastructure and logistical arrangement (organization) to deliver the right package at the right cycle.[c]

SELECTION IN ORGANIZATION ENABLES SPECIALIZATION

In the carbon cycle outlined above, the tasks of photosynthesis and combustion are roughly divided between plants and animals.
They **specialize** in different environments with different survival strategies.
Different organisms can also divide tasks among themselves in a separate context (symbiosis). Within a living organism, **specializations** are **separated** in a fixed context and divided over organs and within a cell over organelles.

a 'Substance' ⇓ mass, energy or information.
b https://en.wikipedia.org/wiki/Hunger_(motivational_state)
c This logistics was clarified by Rothman, Schekman and Südhof. They received the Nobel Prize in Physiology or Medicine for this in 2013

COMBINATION IN SPECIALIZATION ENABLES REPRODUCTION

Biodiversity ⇑ risk coverage. Major changes in the environment lead to the extinction of unadapted species. A wide variety of species with **different** survival strategies makes the survival of some species more likely.
If evolution had only provided for one species, then this species not would have survived dramatic changes in Earth's history. Mutations never come in time.

Mutations sometimes produce variants with new **specializations** that can survive in new environments. The average number of mutations is estimated at 64 for a human individual.[a] That number doubles with every next generation.
In the case of asexual reproduction it remains the same, but the combination of two individuals squares the number of possible child variants that can be exposed to natural selection, even if only a few of them are realized.

Eternal life could realize more variants per couple, but also duplications.
Biodiversity is more served by **combinations** of new individuals who have had a common ancestor for several generations and are equipped with more **different** mutations. They would not compete with the ancients for limited resources.
Biodiversity is served by temporary lives of individuals, by death.

We are used to characterize 'life' primarily by its reproductive ability.
There are, however, life forms that no longer reproduce (sterile specimens, eg mules).
It is probable that evolution has produced masses of sterile forms that we obviously no longer know. Yet a mule is a living creature.

So, reproduction is not an exclusive characteristic of life.

If you, however, involve our conditions of 'culture'

Information ⇓ metabolism in reproduction,
security ⇓ regulated information,
affection ⇓ security in organization,
identity ⇓ specific affection,
influence ⇓ reproduced identity,

then you may recognize its foreshadowing already in Biotics.

The **information** of reproduction is transferred as DNA **securing** a proper development of the reproduced organism. That organism should have a special **affection** to organisms of the same species in order to prevent cannibalism and to enable reproduction. It should be **identyfiable** in order to get any effect (**influence**).

If you call that culture, then it would be a 'culture' of organs within the organism.
The culture (set of shared suppositions and material conditions), however, is the usual *external* interpretation of culture *between* human organisms.

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a Drake,Charlesworth,Charlesworth,Crow(1998)Rates of Spontaneous Mutation(Genetics)0401 148 4 1667-1686
http://www.genetics.org/content/148/4/1667.full

§ 50 REPRODUCTION ENABLES CULTURE

METABOLISM OF REPRODUCTION ENABLES INFORMATION

In the astonishing variety of life, novel authors have a great choice of environments, characters, their appearance, behavior according specific suppositions in **different combinations** they want to **reproduce** with their own **metabolism** of ideas.

New representations as an individual's input supplement old ones or replace them. That is **metabolism**: supposing **difference** in **combination**.
The output is **reproduction**, expression, supposing 'birth', ex-pressing what you carry with you. An expression can contain mutations that evoke new representations.

The **output** of one individual is **input** (**influence**) for other individuals with a different **metabolism**. Your representations may end up in **different** cycles that have their own **input** and **output**. Some elements continue to circulate in **different** subcultures, the common denominator of which is called '**culture**'.
That makes you cautious in your expressions. Too much recognition yields boredom, too much surprise stress and opposition (***Fig. 12*** p29).

This set of shared representations (**culture**) changes with every new generation. Boredom can cause premature death (note b p55). In case of boredom, a new generation is news and strengthens the hormonal desire for children.

Food for thought (news) is a physiological necessity of life (stimulus hunger) and the source of motivation such as Maslow (p80) supposed in his hierarchy of needs: physiology⇑safety⇑love⇑esteem⇑self-realization.

REGULATED INFORMATION ENABLES SECURITY

Too little news gives uncertainty, an experience of **insecurity**.

Too much **information** brings overload and stress.
The **import** must be delayed*, the attention (**focus**) **distributed** over **time** and **space**, as living organisms **distribute** explosive **energy** in small steps over **time** and **space**.

If there is too little **information**, the **input** must be **accelerated**.
You have to come into action and look around to find news in your home, on the road, in work or on vacation.

ORGANIZED SECURITY ENABLES AFFECTION

An urban culture organizes its **securities** (living, working, recreation and traffic) in a fixed **structure** with variable, **free** use (due to **coherence**).

An object of affection, attachment (whether it is a city, a culture or a person) must be recognizable and surprising to the individual (on some points **equal**, on others **different** or **changeable**). The attachment to a culture depends on the personal balance in the traditional **security** and **freedom** it offers.

If it imposes too much **security** or **freedom**, then artistic-religious countercultures offer a counterbalance. Too much certainty (**security**) is compensated in an artistically

free-spirited subculture, too much **freedom** in a religious one.
Social **cohesion** supposes **affection** with a subculture of people with the same **specific** balance and amplitude between **freedom** and **security**.
Freedom is the limit ('zero value'). What is certain can always made more certain.

SPECIFIC AFFECTION ENABLES IDENTITY

On p265 I defined **identity** as '**difference** with the rest and **duration** in itself'.
In its bare form this is name and address, origin and provenance.

A **culture** that gives you a **place** of your own in **space** and **time**, a home and a task, the esteem, the appreciation, the prestige that goes with it, makes a specific **affection** for your self possible. Self-conscious self-esteem is a condition for one's **identity** (**duration** and **difference** with the rest), appreciation for and from that 'rest'.

REPRODUCED IDENTITY ENABLES INFLUENCE

Maslow's 'self-realization' then is the *expression* of that **identity** by saying and doing.
Language is a limited means of expression. You can **connect** your name to what you write (copyright), but what you *do* and its effect is also an expression of your **identity**.
Work creates property - your own (mobile) territory -, and an **outward influence**.
This ensures a feedback of **identity**: a memory of yourself, a recognition by others.

12. CONCLUSION

This study is no more than the elaboration of a method (conditional analysis and synthesis) to find underlying, potentially blocking suppositions of science and design. The aim has been to prune and change old suppositions, enabling design to make new differences, prepared for natural selection.

Making *equal* is not the art. The entropy of sun, wind, water and earth[a] already do so. In order to make a lasting improbable *difference*, evolution used many centuries, but humans are able to do so in seconds by design.[b] In a short time, this has made possible many different objects, shared in (sub)cultures (art, technique and knowledge).

Logic has made a difference between different types of 'or' and 'if', mathematics between different types of equality and repetition, physics between mass and weight, biology between species, and the human sciences between freedom and security. These are just a few examples of design in science.
Once these differences had been made, the empirical generalization could do its job.

Previously unimaginable realities became conceivable in an increasing number of specialized disciplines. Specialization makes deepening possible, but it does not escape unspoken 'ceteris paribus' assumptions about 'the rest'. My attempt to relate these disciplines to each other in a conditional sequence is open to criticism.
It is, however, sufficient to clarify the inadequacy of generalization alone.

The real diversity demands much more distinction.
The *possible* variety hardly has been mined.

Fig. 13 p37 sets out only 3*5 picket posts with a conditional sequence in that area. The place of some scientific objects in that field could be determined reasonably well, but there is room for infinitely more objects that have no name yet.

The question remains, if this field has the correct coordinates, if the picket posts are at a comparable distance, and if all the imaginable can find a place.

I have paid the most attention to the Abiotic conditions, the very basis of endangered life and culture. A complete elaboration would encompass our entire vocabulary and all productions of human culture including biology and humanities.

That goes beyond my power, but this exercise may give confidence in the method of conditional analysis and synthesis.

a Jong(2008)Sun Wind Water Earth Life Living Legends for Design(Delft)TU lecture paper http://www.taekemdejong.nl/Publications/2009/Territory59.pdf

b Jong(2009)The evolution of a design(Delft)Darwin-year lecture in the Botanical Garden for technical plants TUDelft http://www.taekemdejong.nl/Publications/2009/The%20evolution%20of%20a%20design.pdf

DEAR READER,

I can release objects from temporary impressions and hold them as images.
This makes them manageable, even if they re-present a past impression.
Even actions I hold as images, objects. I then can manipulate space *and* time.
That freedom enables me to recognize and want, but also to deny and to refuse.

From my limited memory, old representations come up with every new impression.
They are clear, faded or overwritten and they take other old impressions with them.
What my mind gets from it, I weigh against what I can do and want.
At rest I can manipulate, combine, disassemble and re-assemble differently.

I can project the result back, sometimes express or even realize it.
I used to be unable to imagine and remember many past impressions.
I could not place them in the substructure of my education, someone else's memory.
I held on to these representations for a long time, continuing to build on them.

Fortunately, I am forgetful. I had to write down much and rethink it later.
I have often replaced my weakest substructure (and those of my teachers).
Something was missing from their assumptions, built on concealed quicksand.
The representations that I had built on them went wrong or fell over.

I did admire the beautiful superstructure from that memory of others, but not their hidden substructure. I did not share their assumptions. They did not give up that capital of expensively paid study, no matter how weak it seemed to be. I now suspect our language as a cause of that weakness, but how do you explain that in words?

As a teacher I had to continue building high on collectively accepted soil first,
before I could demolish it as a delusion.
Explaining the common heritage is expected, but not the undermining afterwards.
Colleagues earning money with old certainties could not laugh.

On the stage I had learned to empathize with a role that does not contain my own text.
I played the collective error so, that it drowned self-confidently in its swamp.
The audience laugh when you sink through the shelves in the middle of a scene.
Humor does the same thing: a joke is funny, by changing an unnoticed assumption.

Science is humor, it frees you from what everyone previously believed.
Faith is loving lost past, loving the promises from an ancestral dream.
As long as science is no longer a design, it is also faith.
Compliments then convince more than arguments.

After this 25 years delay of teaching, I got the freedom to resume my own thread.
Where was I in the 60s, 70s? I searched in the notes from that time. 'Continuous amazement, detachment, self-objectification!' wrote the schoolboy of that time.
The student urban design understood that science is a design and not the reverse.

The happy 80s brought children on my path, although I was not their biotic father.
If everything is new, then there are no assumptions that make wonder evaporate.
Parents transfer them. You came for their pleasure. They promised a carefree future.
Now the earth is eaten empty, full of people who have been promised the same.

As a teacher in the 1990s I was confronted with more assumptions that I cannot share.
Every representation has suppositions. Even more hide below. I tried to write out this series[a], with 'and so on' as a result. Where is the end? Where was the beginning?
Generalization has a boundary. Below that, there are only differences.

Nothing can be observed, chosen or thought without a difference.
Categories exist because of the difference between them, not by equalities inside.
"There is no other being than to be different" wrote the author of Prometheus[b] earlier.
Passing a boundary, the difference shows what 'not' means.

We rely on equality, but there are still differences below.
If generalizations make no difference anymore, then words do not make sense either.
Words deceive, images too, but differently. Their foundation slipped away.
My library fell. One species is still abundant among the debris: doubt.

My dear opponent dr. Sjoerd Zwart did not agree with me in nearly everything I wrote.
"Carnap already tried what you want, and failed!" So, I studied Carnap's failure. Sjoerd stressed the rules of classical logic and empirism: "Design is simply combining truths!"
No one stimulated me more to find words for methods beyond probability and truth.

My dear teacher Karel de Vlieger avoided the shortcomings in my math and physics.
That required many patient explanations and tutorials. I often rewrote my texts.
My dear biologists Jayand Achterberg and dr. Dong Ping checked my biology.
I sincerely thank these true friends for healing or reinforcing my doubts.

What, however, do we share with words? What do you see in my drawings?
These are only representatives of my thoughts. I am not present myself.
Have I misunderstood your discipline? Write me the proper rules.
I may ask for changes.

http://taekemdejong.nl/,

taekemdejong@outlook.com

a Jong(1992)Kleine methodologie voor ontwerpend onderzoek(Meppel)Boom
b Bruggen(1924)De grondgedachte van Prometheus(Amsterdam)Maatschappij voor goede en goedkoope lectuur

INDEX

bold: see footnote on the page

A

B

C

D

E

F

G

H

I

J

K

L

M

N

O

P

Q

R

S

T

U

V

W

X

Y

Z