S4002

law, ethics & philosophy of science

workshop part I
philosophy & ethics of science

expanded auxiliary study materials

MUNI
SCI

jan havliš
: national centre for biomolecular research
:: laboratory of functional genomics and proteomics

recommended reading

[01] Karl R. Popper, **The Logic of Scientific Discovery**, *Routledge* 2002

[02] Alex Rosenberg, **Philosophy of Science**, *Routledge* 2013

[03] Carl G. Hempel, **Philosophy of Natural Science**, *Pearson* 1966

[04] Richard Dawkins, **Climbing mount improbable**, *WW Norton* 1997

[05] Jaroslav Flegr, **Frozen evolution**, *BookSurge Publishing* 2008

[06] Jonathan Marks, **What It Means to Be 98% Chimpanzee**, *Uni Califor Press* 2002

[07] Paul K. Feyerabend, **Three Dialogues On Knowledge**, *Blackwell* 2011

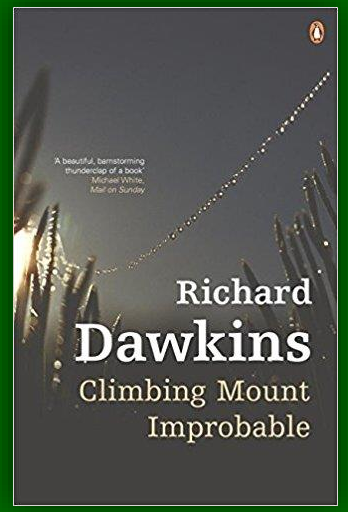
[08] Paul K. Feyerabend, **Against Method**, *Verso* 2010

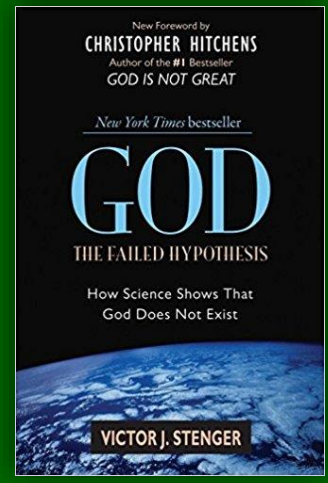
[09] Victor J. Stenger, **God: the failed hypothesis**, *New York* 2007

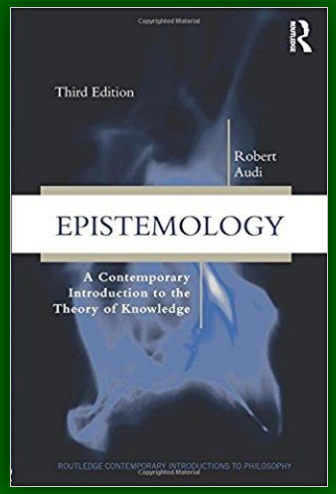
[10] Stanislaw Lem, **Summa technologiae**, *Uni Minnesota Press* 2013

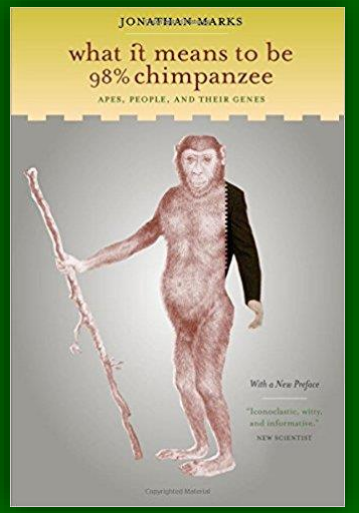
[11] Robert Audi, **Epistemology: A Contemporary Introduction**, *Routledge* 2010

[12] Daniel Kahnemann, **Thinking – Fast and Slow**, *Penguin* 2012









cognition

what do you see?

what does it mean to see?

: cognitive functions
:: cognitive biases
::: sensorial and rational

: mind and brain
:: senses
::: sight ...

how do you recognise what you see?

what does it mean to recognise something?

: problem of classification and typology
:: sharp or fuzzy categories?
::: degree of similarity
: problem of unambiguous definition

: sensory illusions
: cognitive illusions

how do you know how recognise anything?

what does it mean to recognise something?

: problem of classification and typology
:: sharp or fuzzy categories?
::: degree of similarity
: problem of unambiguous definition

: sensory illusions
: cognitive illusions

how could you be sure about what you see?

: difference between the seen and what you see
:: optics, neurology, psychology
: reality
:: metaphysics of reality

: reality
:: phenomenon vs noise
::: empiricism
:: world exists independently on mind
:: world's existence depends on creator
:: world exists only in mind

how do you explain what you see?

how could it happen?

: course of actions
:: determinism
: network of actions

: check all possible variants of causalities
:: evaluate the possibility
::: *once you eliminate the impossible, whatever remains, no matter how improbable, must be the truth*

what does it mean to understand?

: modelling the reality and applying it to explain/understand

how do you share the explanation?

: see the difference between description (facts) and explanation (their causalities)
: argumentation
:: thinking

: the circular argument, in which theory and proof support each other
: the regressive argument, in which each proof requires a further proof
: the axiomatic argument, which rests on accepted precepts

how do we survive in the world?

how do we process the info from around us?

: knowledge acquisition
:: observation, sorting, concluding, predicting, deciding
: mental reflection of world / mental model
:: mental representation of the world and its rules

: knowledge serves
to connect past with the future
: knowledge serves
to successfully deal with challenges

how does our mind work?

: system 1 / rabbit
:: fast, emotional, adaptive, unconscious
: system 2 / turtle
:: slow, rational, non-adaptive, conscious

: system 2 can be trained
: system 1 can be easily fooled
:: in non-adaptive situations

how could the knowledge acquisition fail?

: sensory-mental distortion – cognitive dissonance
:: we may not see what is right before our eyes
::: cos we do not know we have to look at it
: too complex problem
:: we may not consider all potential influences
: errors
:: we are fallible and make mistakes
:: we may not be sufficiently educated
: previous, limited knowledge
:: we may not be able to consider new ideas due to lack of preparedness
::: we often do not question old knowledge to move forward
::: we often neglect what we do not find important/interesting

: intuitive acquisition is more prone to fail than methodical one

basic cognition

Ivan I. Shishkin – *Birch forest*
oil on canvas
The Tretyak Gallery, Moscow, Russia

cognition is elemental to living

our mind is hard-wired to cognition

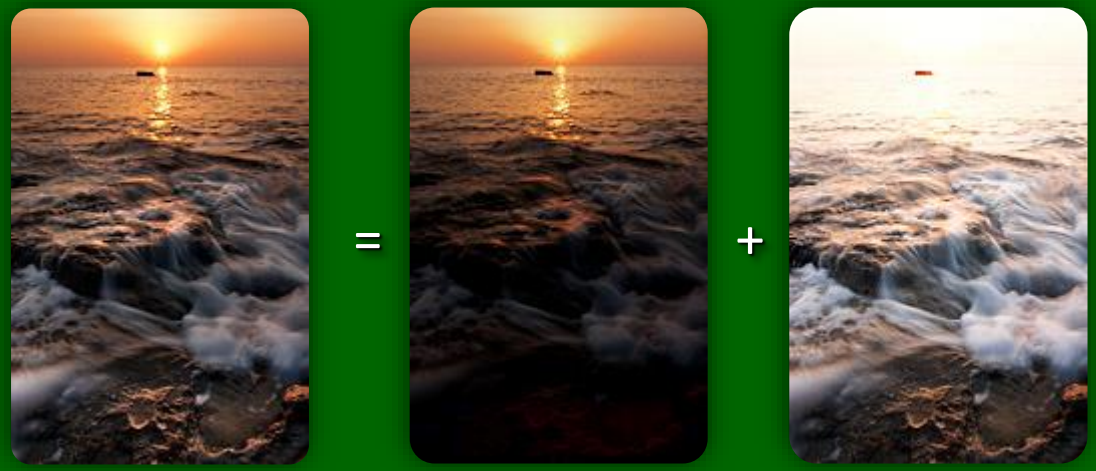
: to observe, to sort, to concatenate and to predict

videmus modo per speculum in ænigmatibus

we see only through a mirror and in enigmas

what does the eye see

eye seen brain made

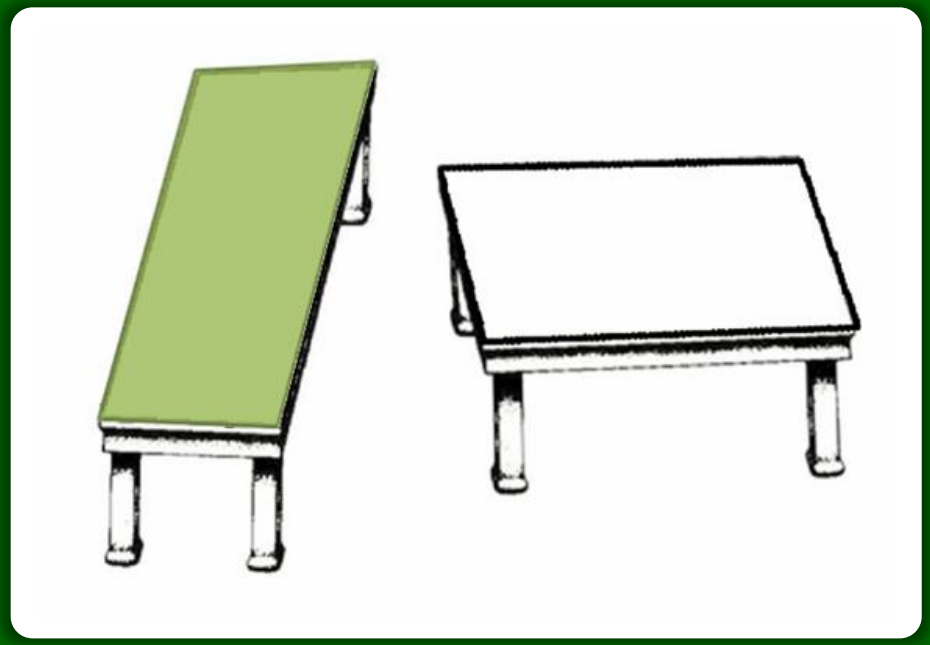


final picture = two focal planes: distant + near

visual attention

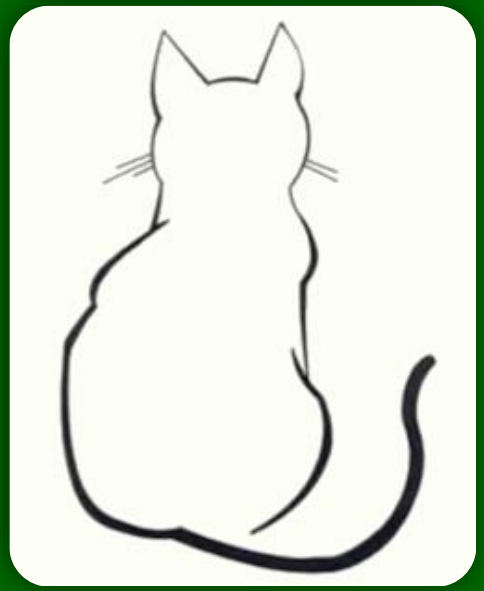
: **sight** – primary sense (75 – 90 % of information input)
:: hearing 20 %, smell 5 %, touch 4 %, taste 1 %
: **hand** – grasping (connection of hand, tongue and frontal lobe)

: **pattern recognition**
: **generalisation**
: **classification**



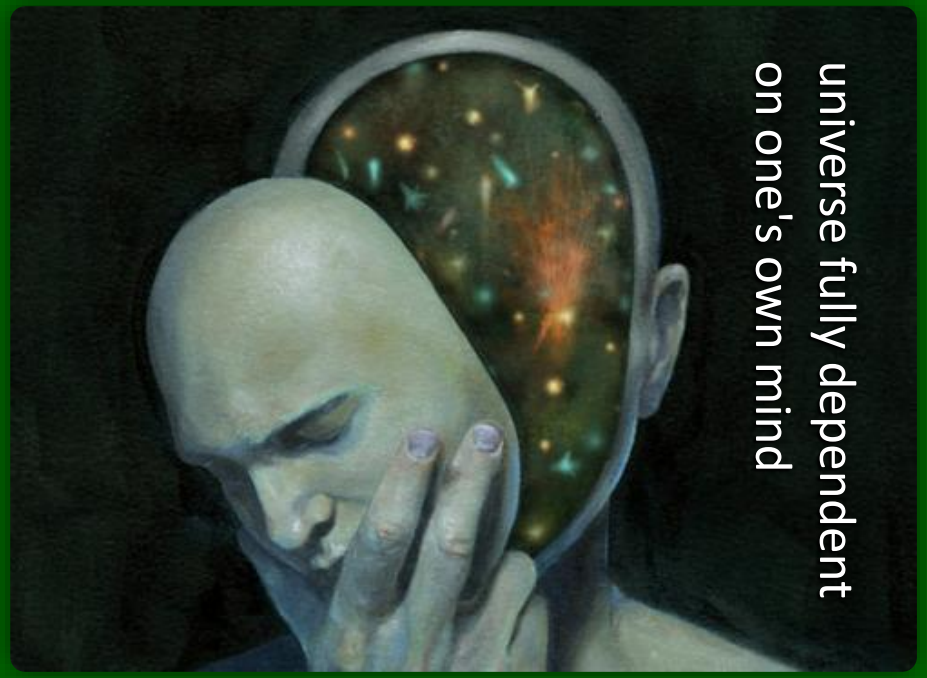
how do we recognise specimens?
: how much a different is still the same?

what is the same?
what is the similar?
what is the different?



different level of *catness*

possible natures of the universe

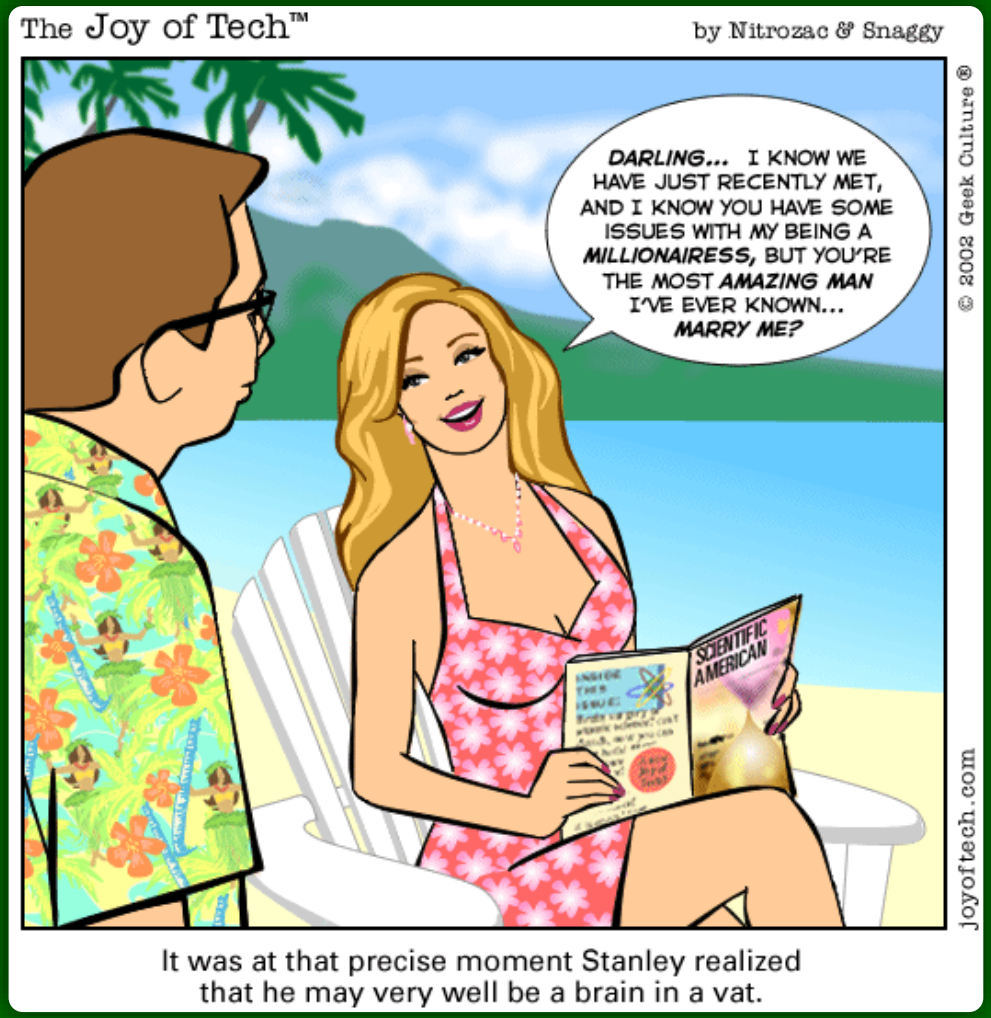


metaphysics inside

cogito ergo sum – i think, therefore i am
: is this the only sure thing?
: how do we know there is anything outside?

basic axiom of science
: there is something outside of our mind
and it is independent of it

brain in a vat
: is our existence a simulation
or is it reality?



: we have no reasons to believe in objective reality,
but we have no other option than to act as it exists
David Hume

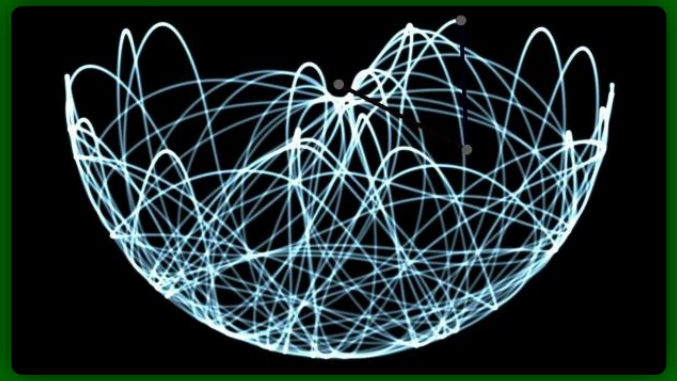
causality and determinism

mechanical
same cause(s) → same phenomenon

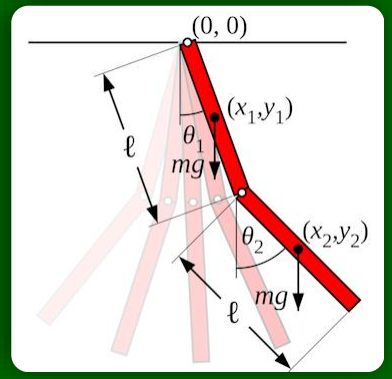
probabilistic
same cause(s) → set of phenomena with different probability

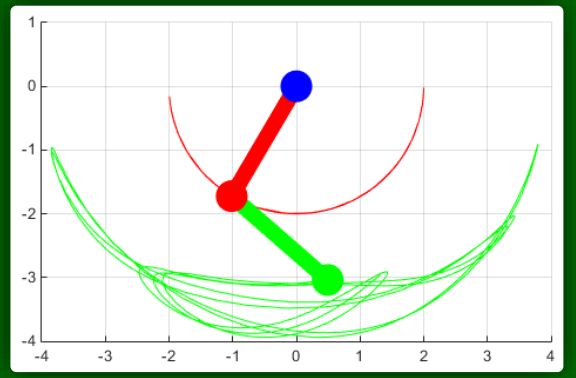
cause(s) → phenomenon

: what is the course of actions?
: can it be reverted?



chaotic
same cause(s) → similar phenomenon





***modus vivendi* in surrounding environment**

originally: *hominidae* were frugivores, often a prey of predators in savannah
today: solution for perpetually increasing social demands

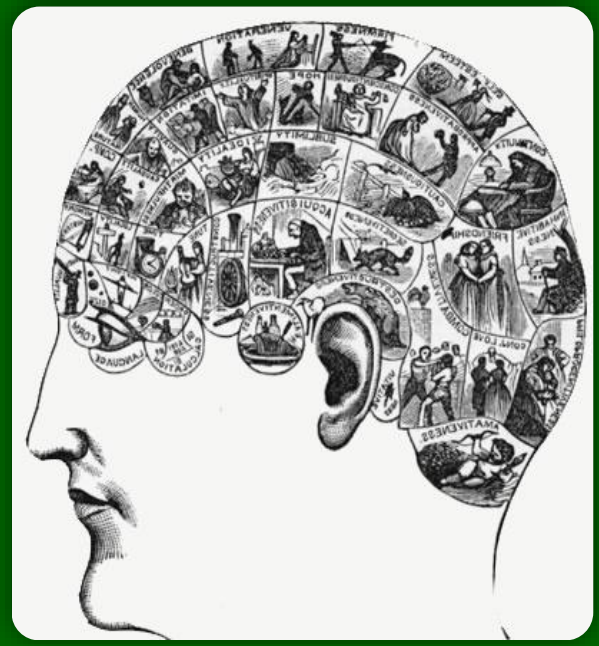
: perception

: attention
: memory

: communication

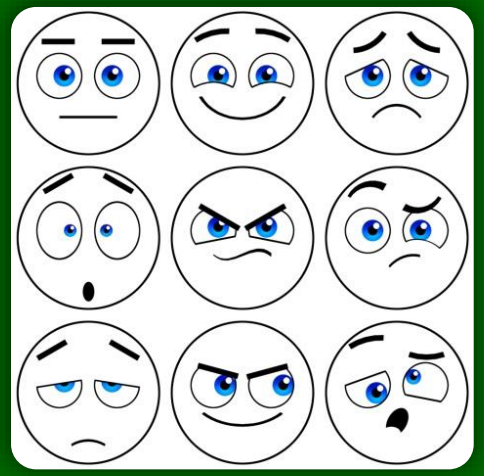
: reasoning
: calculating
: problem solving
: decision making

: language



cogitatio – thinking

human cognition model – dual process theory
aka **thinking, fast and slow**



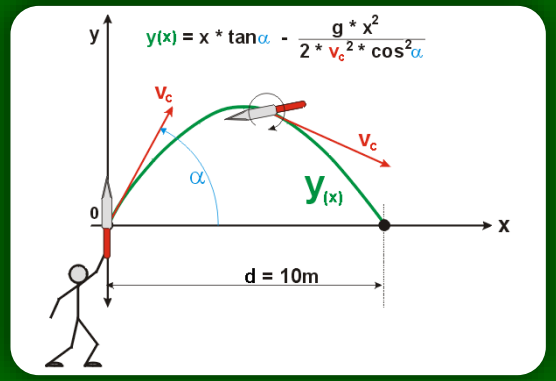
system 1 (rabbit/hare)
: automatic and quick
:: compares similarities and intensities
: intuitive and instinctive
:: no sense of voluntary control
: most of the time, our cognition is driven by system 1
:: rather efficient in adaptive environment, but may fail elsewhere

system 2 (turtle/tortoise)
: effortful and slow (and lazy)
: analytical and objective
:: a feeling of voluntary control
: eventually fixes system 1 failures
:: evolved for non-adaptive situations
: **could be trained**

science is a superposition to natural cognitive mechanism
: maximises influence of analytical thinking (system 2)
:: by applying methodical cognition

some tools of system 1

intuitive ontologies
: intuitive physics, biology and psychology
: five categories
:: person, animal, plant, artefact, natural object



basic counting
: automatic counting up to 7

: plants are alive but do not move

: things & natural objects do not move on their own

some tools of system 2

advanced counting
: parietal lobe
:: arithmetic

analysis
: frontal lobe

language
: complex neural networks

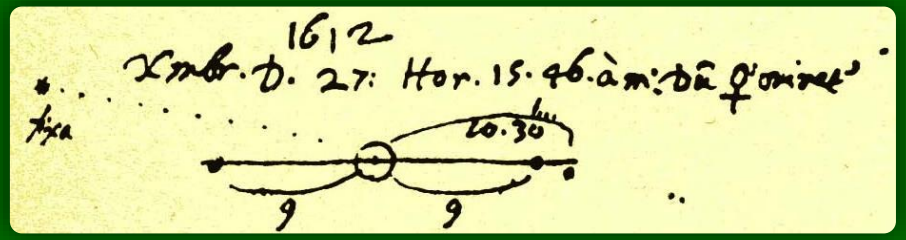
tools of system 2 could be trained!

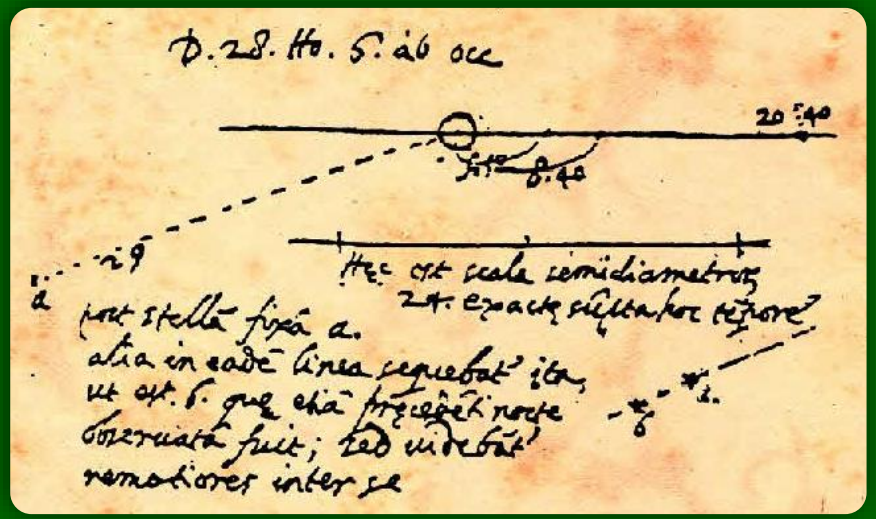
time-scale & complexity of phenomena in reality

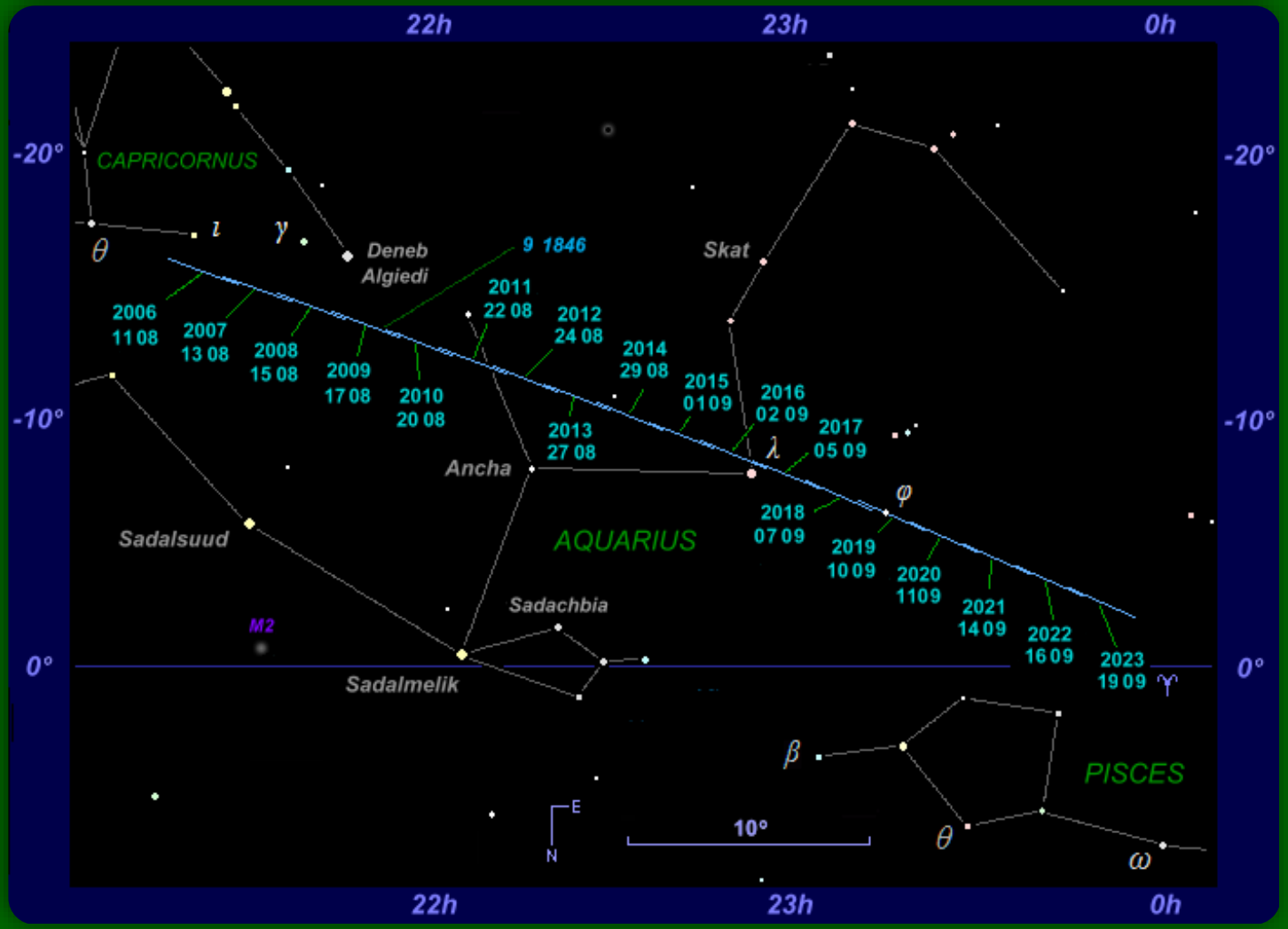
mixing ethanol + water releases heat & decreases volume
mixing acetonitrile + water absorbs heat & increases volume
: phenomenon takes minutes up to days

Schlumbergera blooms only at 12 – 15 °C
: to see it takes days up to weeks

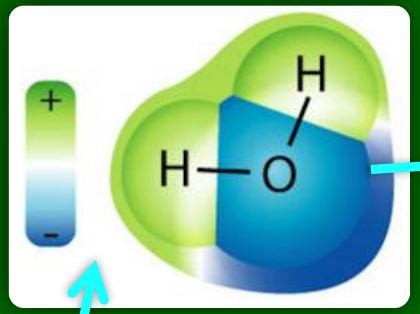
phenomena regarding sun
: related phenomena take years, up to tens of years

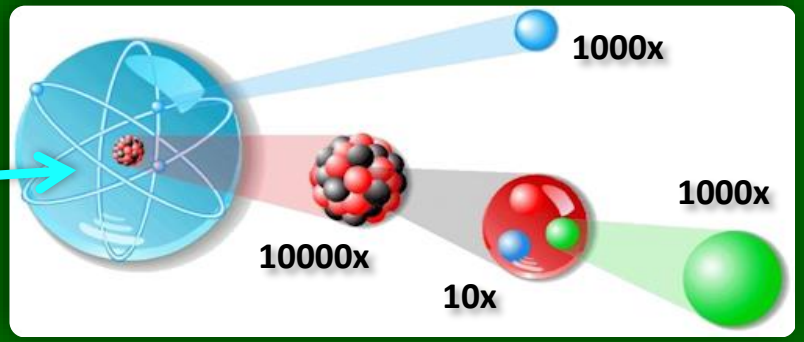




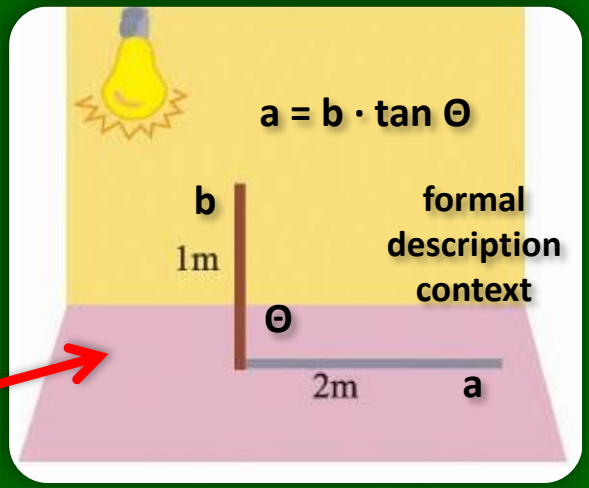


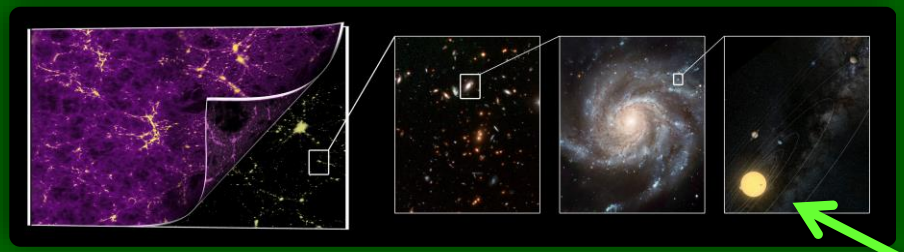
apparent movement of Neptune is almost indistinguishable due to very long orbiting time : such phenomena take decades or centuries





phenomenon context

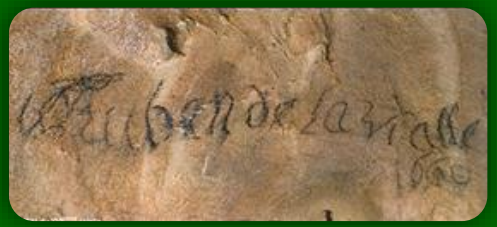




: one real picture exists
: but four different pictures were seen

a story of three caves (Niaux)

11000 B.C.E. – author
: he or she knew what it means



1660 C.E. – Ruben de la Vialle
: he saw the picture, but was not impressed

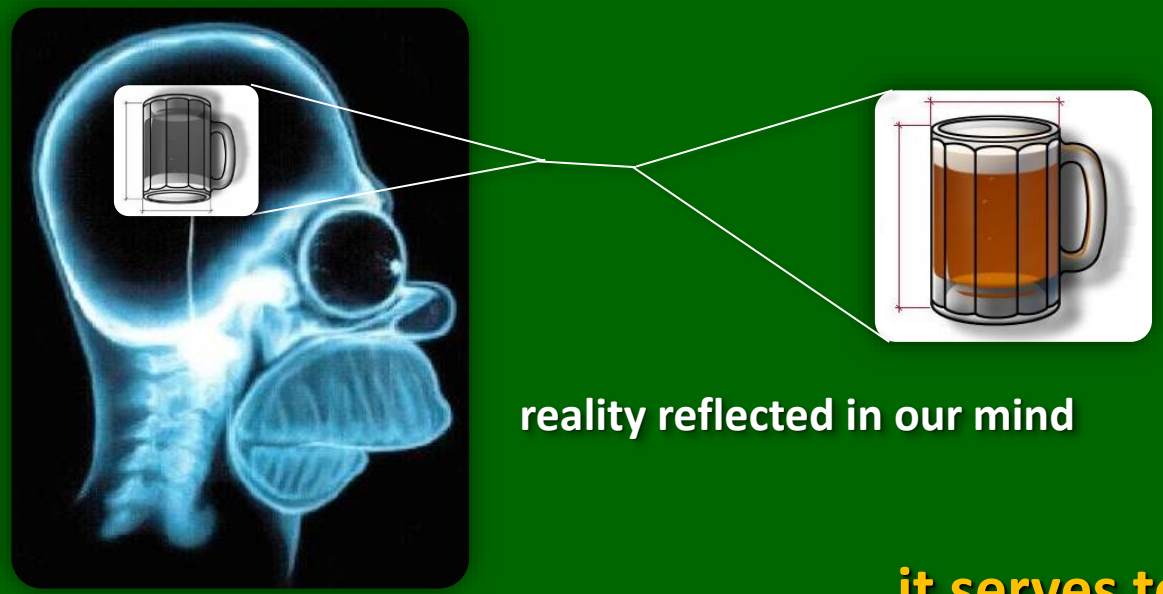
1864 C.E. – Félix Garrigou
: he guessed the importance of the picture

1971 C.E. – Jean Clottes & Robert Simonnet
: they already knew how significant it is

what we know
: ~~**paradigm**~~ influences ~~**data**~~
what and why we observe

: ~~**data**~~ then retroactively influence ~~**paradigm**~~
what and why we observe
what we know

knowledge is **contextual**



reality reflected in our mind

extended cognition
reflection of world created by means of cognition

: subjective reflection
:: model of world in mind

: intersubjective reflection
:: intersection of subjective reflections

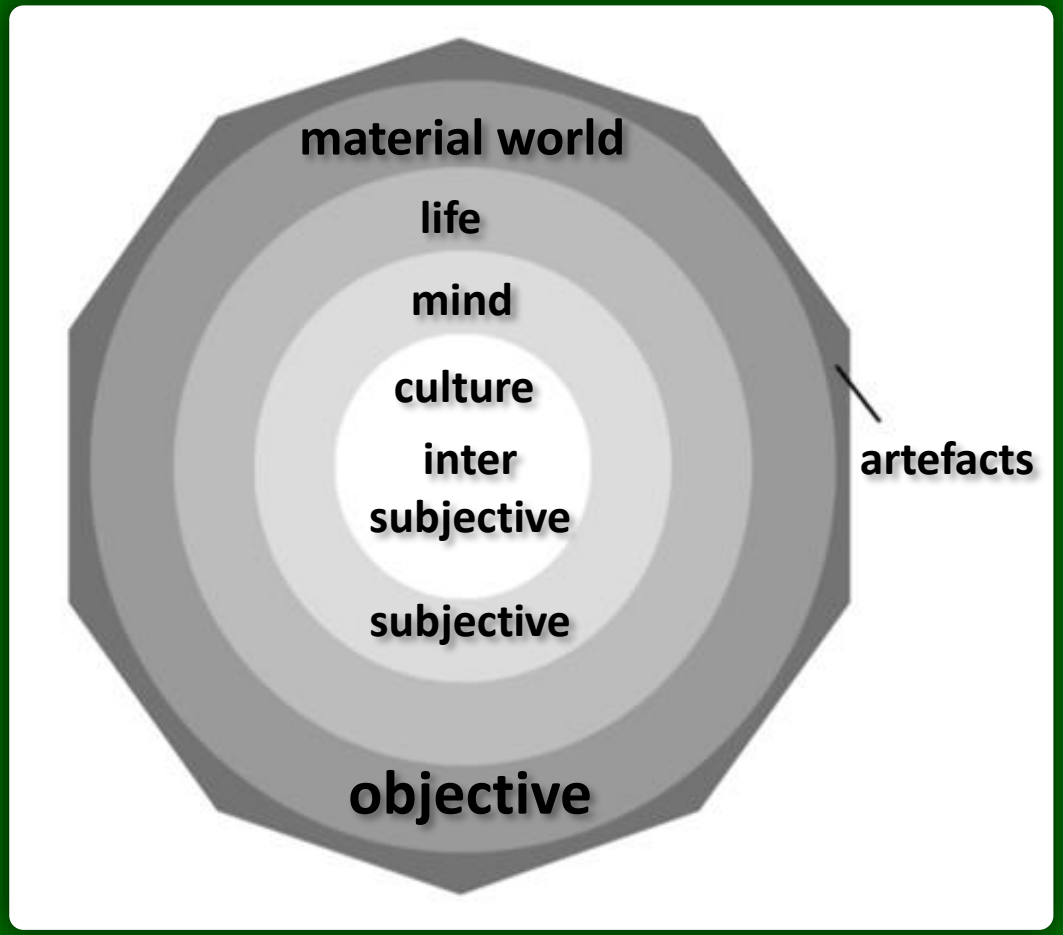
it serves to understand (model) the world around us
: to relate what happened to what is going to happen

cognition + experience = knowledge

can you read the wolf without experience?

: scientific reflection
:: attempt for methodic, universal explanation
::: method – **scientific method**
(rather set of methods, none of them is universal)

science is **a superposition** to **natural cognitive mechanism**
: maximises system 2 influence by applying methodical cognition



material world
: objectivity
:: ...*per speculum in ænigmatibus*

subjective reflection – mind
: model of the material world
:: cognitive problems of introspection

intersubjective reflection – culture
: intersection of subjective reflections
:: reality apparent & genuine

importance of intersubjectivity

: **irreplaceable role** for a life of man and society
:: creates environment and forms interaction mechanisms
::: law, ethics, religion, economy (money), art

even it exists only in our minds, for a life of an individual is real

human **mind** is able **to draw relevant conclusions from incomplete information**

: information is **always incomplete** (induction), the **degree of incompleteness** matters

: **we decide** based on these unsure conclusions **intuitively with a confidence**
:: we have to, even if information only indicates
:: we pay a high price – **(self-)deception**

:: deception is effective and must be punished (interaction strategies)
::: strategy of preventing the deception and of reaction to it
:::: e.g. gossip – spreading disrepute of liar and lies
::::: surprisingly more effective than a direct punishment
::: science must uncover deceits (& errors), cos it relies on formerly achieved knowledge

: emotion recognition efficiency
:: machine 93% vs man 68%

mind – both, **rational** & **irrational**

: the same mind designed a tallow lamp and left a ursine tooth embedded in a rock wall

curiosity (+ critical thinking + diligence) = **source of knowledge**
not nosiness ☺

cognitive biases or how system 1 tricks us

if we do not use system 2, this is going to happen

: decision-making and behavioural biases
:: deviation when confronted with a specific situation
::: e.g. tendency to judge situation in a way we want to have it
:::: anchoring, power of evidence (fish in a pond)

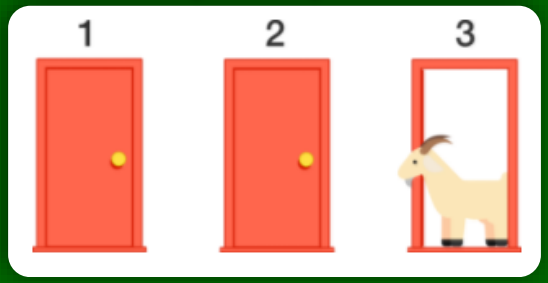
anchoring
: guess how many African states are in UN
:: with & without spinning the wheel of fortune

: biases in probability and belief
:: misjudging the probability of phenomena
::: e.g. tendency to think future probabilities are altered by past actions
:::: Russian roulette, Bertrand's box (card) paradox, flipping the coin
:::: Monty Hall paradox

Bertrand's card paradox

: social biases
:: systematic misjudging of a social situation
::: e.g. tendency to give preferential treatment to members of own group
:::: cognitive arrogance, groupthink, group stupidity

Monty Hall paradox



Russian roulette

: memory errors and biases
:: the changes in recall of a memory
::: e.g. illusion of memories from before the age of four
:::: suggested truth

the most important cognition biases applicable in science

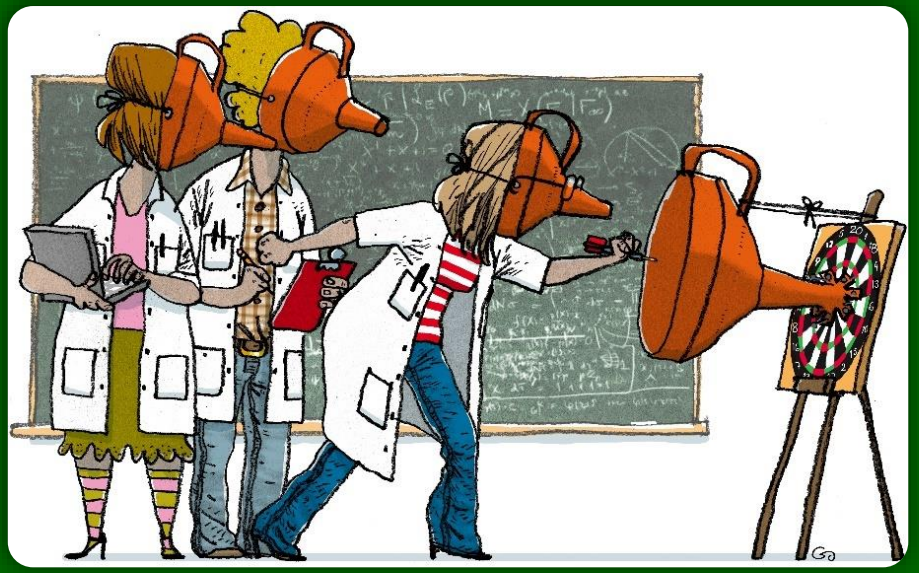
: we tend to **ignore counter-evidence**
:: we rather believe to what approves our opinions

: we tend to **create an explanation at any cost**, even it is wrong
:: we rather accept quick and dirty explanation that spend efforts thinking

: we tend to **move on intuitively**
:: we are lazy to use system 2 in planning

: we tend **not to see the bigger picture**
:: we mistake what we remember for what is

: we tend to **eliminate uncertainty (loss) at any cost**
:: we rather cheat (risk) than admit an error (loss)



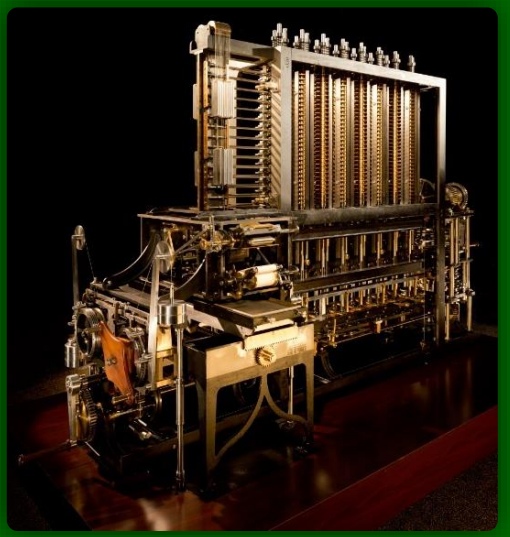
: we tend to **be easily mislead by manipulative presentation**
:: the first impression makes 70 % of the opinion

: we tend to **defend members of our group** even we are wrong
:: distortion or withholding of information in a name of social consistency, collective reasoning, self-assigned higher moral stance, opposition demonisation, insufficient & exaggerated or misleading responses to critics; high level of group anxiety (groupthink/ group stupidity)

systems theory

science ~ applied system theory

frame for **analysis** & **description** of any **group of objects**, which in concert **have a resulting effect**

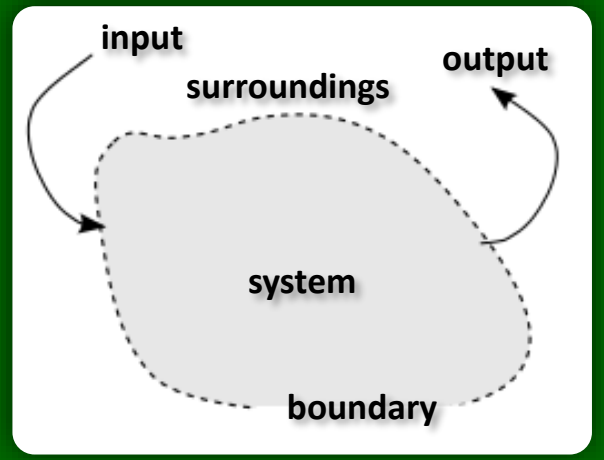


system

: structured set of elements with mutual relations
: manifested to its surrounding differently than a mere set of unrelated elements

set-up
: practical realisation of a system (material system)

system and exchange with surroundings



open
: exchange of material, energetic or information fluxes with surroundings

closed
: exchange of energetic or information fluxes with surroundings

isolated
: isolated from surroundings, no inputs neither outputs into surroundings

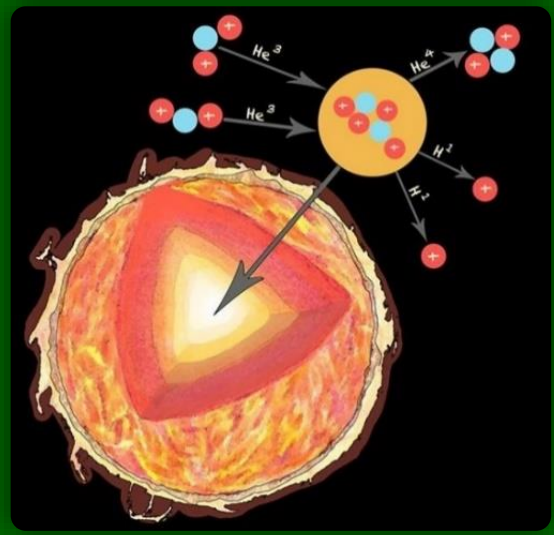
hierarchic structure of system

exchange inside of the system
: signal (material nature; particle, molecule, sound, *etc.*)

element
: it has input and output (relation, feed-back)
: no inner structure (black box)

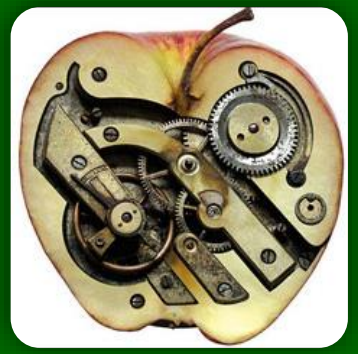
: **inner element**
:: communicates only inside of the system
: **outer element**
:: communicates inside and outside of the system

sub-system
: may be more complex than a system (plane pilot; to crack nut with laptop)



system
: behaviour of the system – graph of output values

supra-system
: cell → organism → evolution



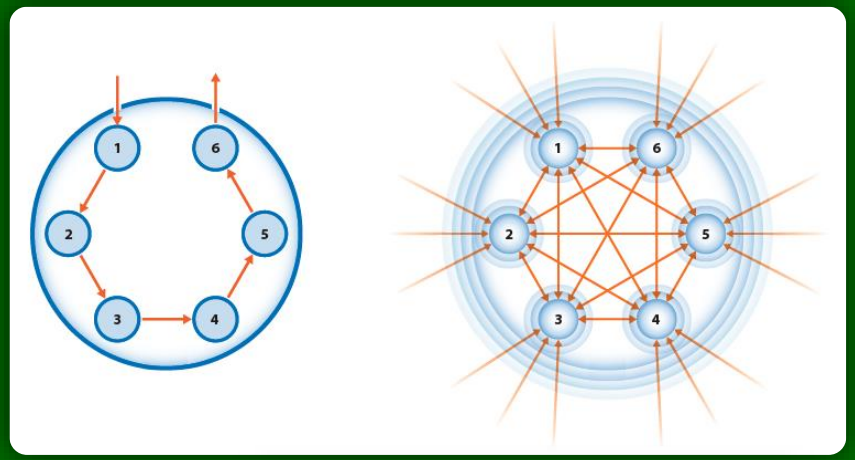
hierarchy of knowledge

: what? – **description** of system (descriptive science)
:: what? – **outputs of peripheral elements** (black box)
::: how? – **mechanism** of system (how the system works)
:::: why? – system **„purpose“** (teleology; from supra-systems properties)

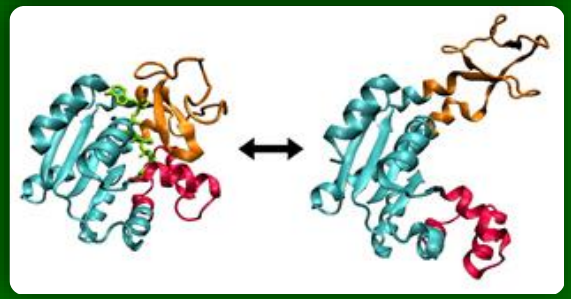
reductionism (methodical/hierarchical)

vs holism
: far east, absence of science

we can decompose (reduce) observable empirical reality into (sub)systems
: a system, being it-self a sub-/supra-system, can be studied separately



emergence
: the whole is more than its parts
:: from elements/subsystems non-deductible consequences for a system



reductionism is often mistaken with **algorithmic compressibility**
: *de facto* determination of information content
: it allows predictions based on application of the algorithm

ABFTHJRSCBLOYEAXVY
: algorithmically incompressible

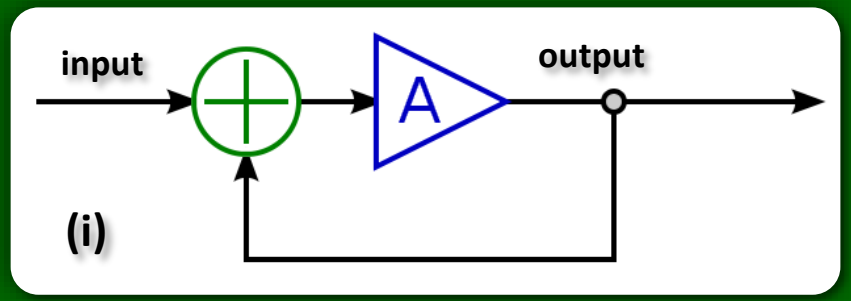
ABCABCABCABCABCNN
: algorithmically compressible – 5x[ABC]+[NN]

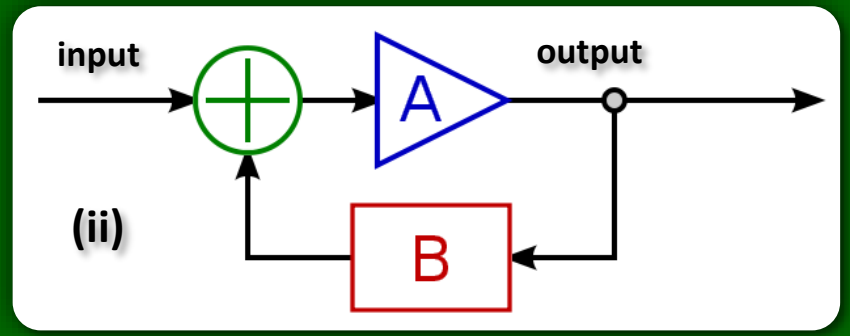
control and regulation in systems

cybernetics (*κυβερνητικός* – art of steer, to control)
: science on control and signal transmission inside of the system
: N. Wiener, W. R. Ashby, J. von Neumann & H. von Förster
: today part of informatics

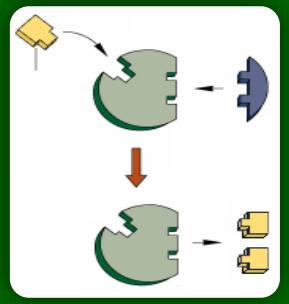
feed-back
: tool of control and regulation

direct (i) or **indirect** (ii) influence of signal from output on input of element



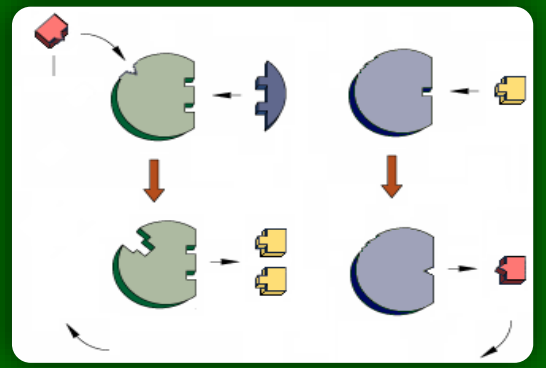


control
: interference into system
:: no possibility to directly observe an effect



B < 0 = negative feed-back
: impedes; enzyme inhibition

B > 0 = positive feed-back
: amplifies; chain reaction

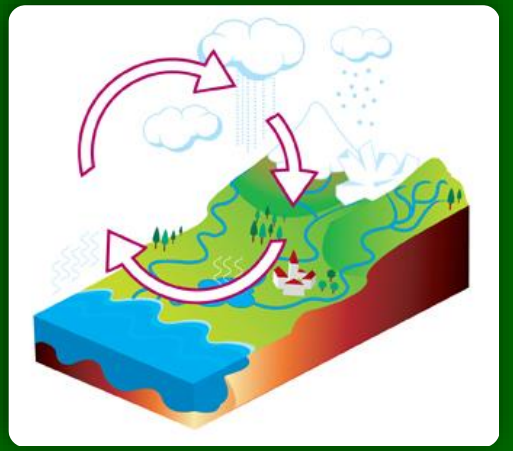


scientific model & modelling

: **model** of **the observed**

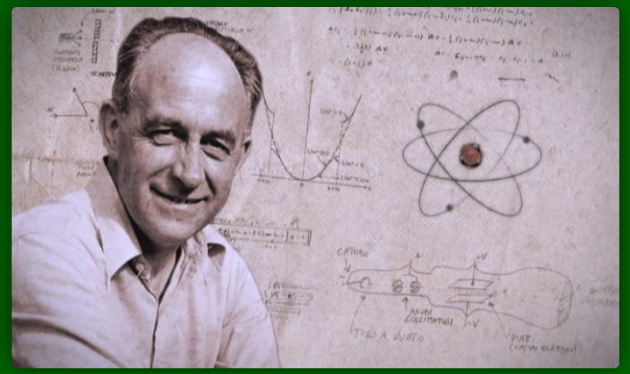
: **technical**
:: how **does** smth **work**

: **scientific**
:: how **does NOT** smth **work**



we create a **model** and compare it **with reality**
: all is fine → ☹; several different models may behave in a same way
: something is wrong → ☺; we excluded one hypothesis!

... there are two possible outcomes
: either the hypothesis is confirmed, then you've made a measurement
: or it is not and you've made a discovery ... Enrico Fermi



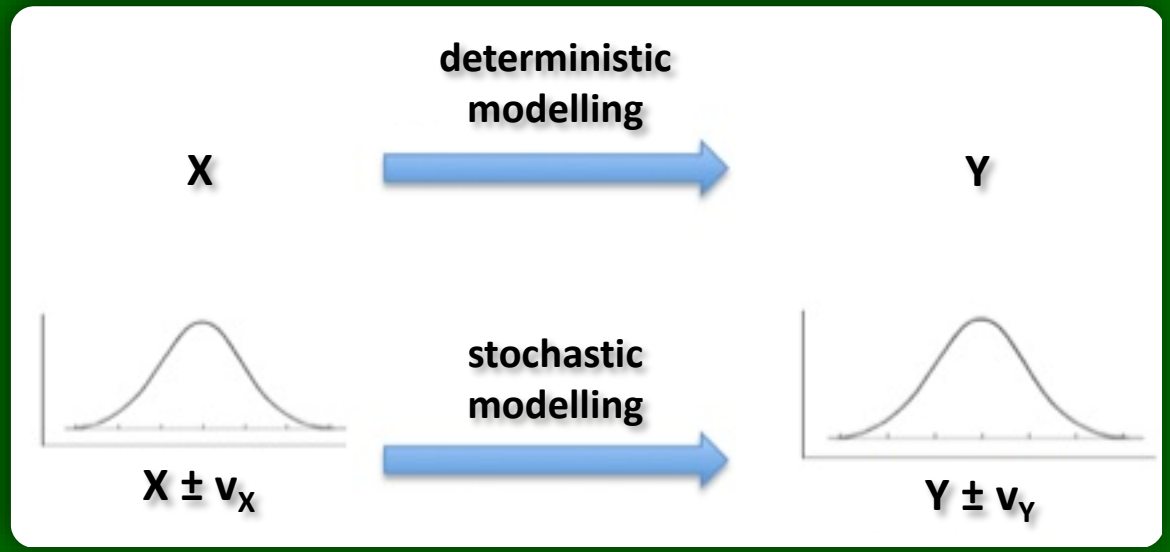
important questions in scientific modelling
: what is an element in a system & what are its relations?
: how deep could i go into a system?
: what is already a vicinity of a system?

: the **studied system** is always **arbitrary**
:: it serves to approach complex (holistic) reality by reduction of complexity

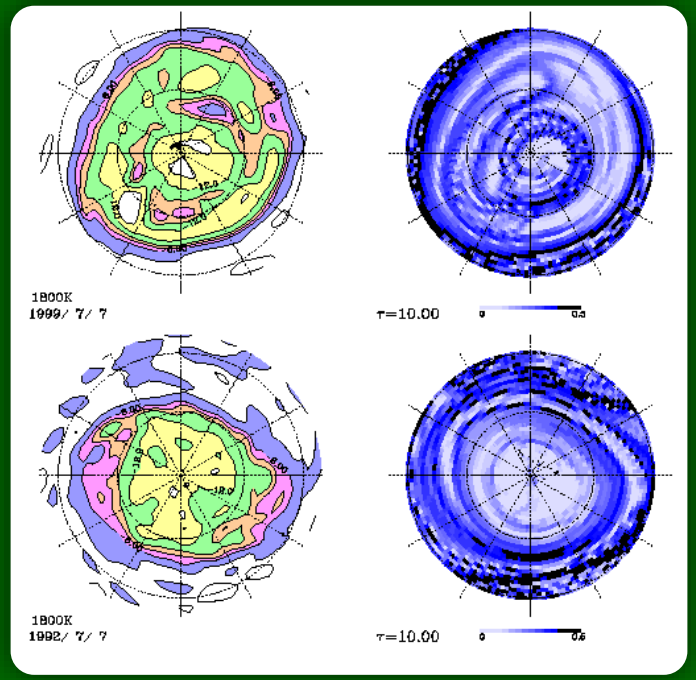
models depend on the observed determinism

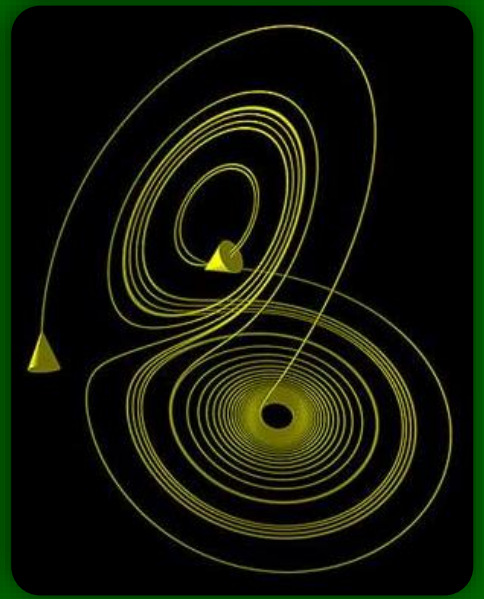
deterministic modelling
: 100% predictable outcome
: e.g. simple mechanistics...

stochastic modelling
: outcome predictable only with certain precision



chaotic modelling
: special type of deterministic modelling
:: unknown initial conditions
: e.g. non-equilibrium processes
:: attractor

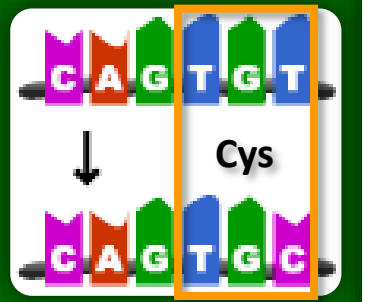


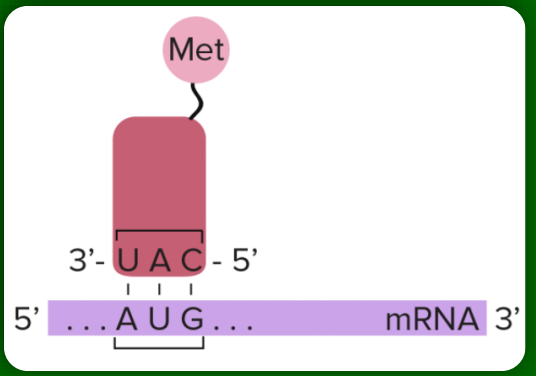


art of a science lies **in searching** for what's **substantial** to the system
: phenomenon is never isolated, but always part of supra-systems

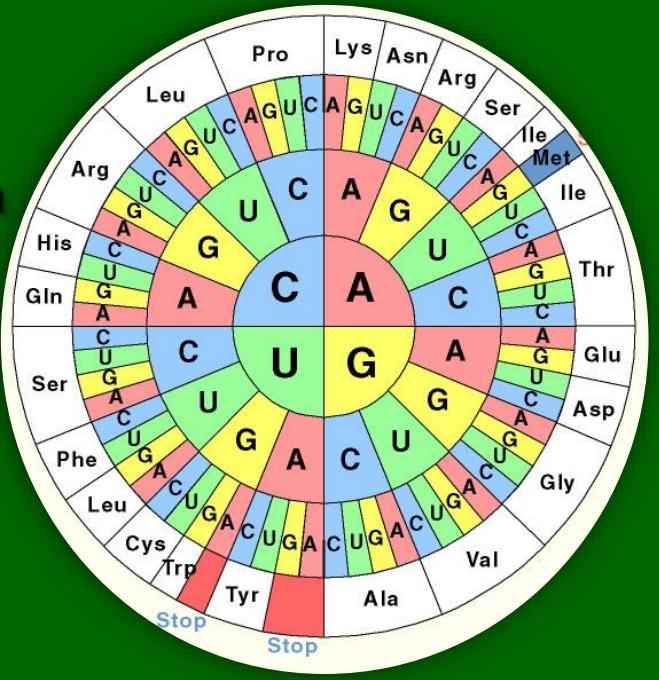
an art to recognise, what is **studiable phenomenon**
: anything could be modelled

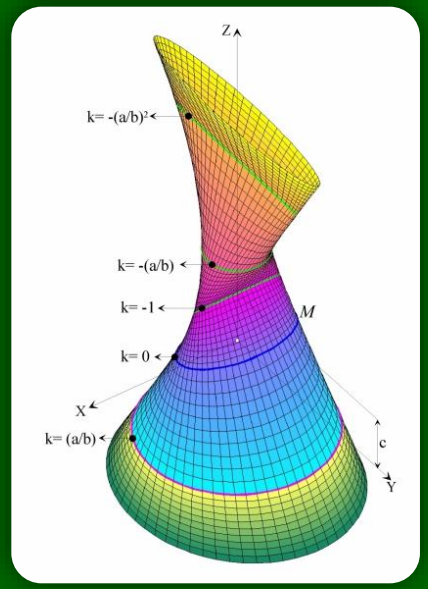
what is **general** (integral to model) and what is **special** (non-integral)?





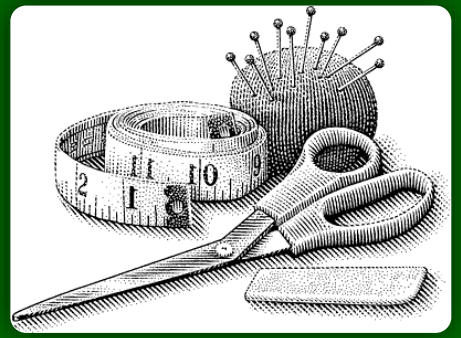
example – silent mutations speak
: on genetic level (mRNA translation model) – no change
: on proteomic level – other tRNA causes different folding & thus expression





... creators of mathematical models are like crazy tailors; they sew all kinds of cloth styles hoping, that some of them could be put on ...

Stanisław Lem



we make models **of relation of dependent variables** (R) to **independent variables** (A, B, C, ...)

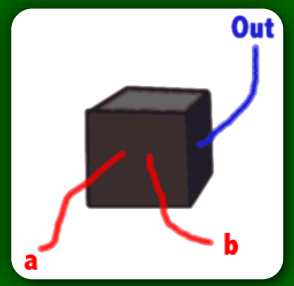
$$R = f(A, B, C...)$$

hard modelling
: based on physico-chemical models

soft modelling
: based on approximation of real function

: hyper-flat of approximated function
:: relation between dependent & independent variables
:: substitution for numeric model

black box

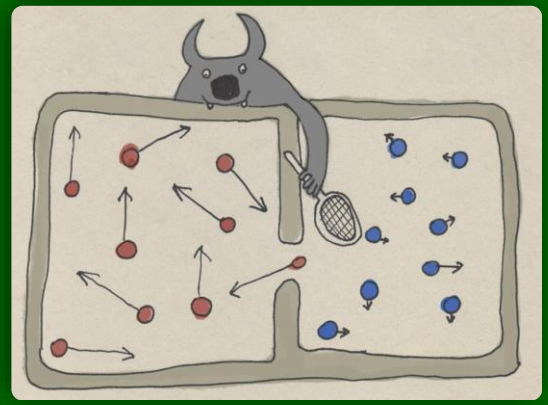


we know inputs and outputs
: **NOT** the way of their **transformation**

enables us to study **complex** and **unknown** systems
: **we are not** dependent on actual state of other field of science
:: scientific „division of labour“

thought experiment and **paradoxes**

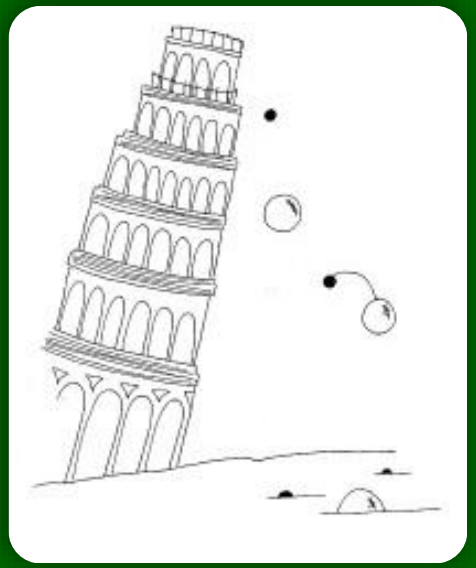
logical *a priori* procedure of modelling of phenomena
: non-empiric
: intermediate step between postulates and experiment
: substitution of practically impossible experiment



: Maxwell's daemon

: Einstein & catching the electromagnetic wave

: Aristotle, Galileo & two connected flying coins



: questioning, disproving an old theory
:: evidence by contradiction (*reductio ad absurdum*)

: proposing a new one

: justification of an existing theory

*: does the lowest rational number higher than 0 (**n**) exist?*
:: each rational number is divisible by 2
*:: thus if **n**, then also **n/2**, and thus no **n** could exists*

new levels of cognition
or
research community as meta-scientist

scientist

: very high risks (long-term & complex goals)
: basic question asked – **why?**
→ paradigmatic shifts of knowledge (due to synthetic work)

researcher

: low risks (short-term goals)
: basic question asked – **how?**
→ small shift of knowledge (not enough synthetic work)

so, are researchers useless? no!

: **external cognition**
:: records; scientific publications and databases

: **distributed cognition**
:: *ad hoc* teaming
::: MMORPG
(*massive-multiplayer online role-playing game*)

science – quasi-teaming and interaction using external cognition
: researches as well as scientists do matter

epistemology
methodology of science

how do you acquire relevant knowledge?

how do you acquire relevant knowledge?

: asking the right questions (constructing hypotheses)
:: general (disprovable, unverifiable) **or particular** (verifiable, undisprovable)
: proper testing
:: hypothesis serve to make unique predictions as if true, which have to be tested if they really are
:: hypothesis > prediction > test > reformulation of hypothesis > new prediction > new test ...
::: eventually you cannot disprove it and it remains accepted

what does it mean science?

: acquiring relevant & reliable knowledge
:: testability
:: natural vicissitude of knowledge (paradigm shift)
: universality of knowledge
:: sharing and conveying throughout the knowledge

: scientific method
:: universal & general approach

how do we conduct science?

how to acquire relevant data?

: repeatability & reproducibility
: precision & accuracy
: selectivity & sensitivity

: good laboratory practice
: pseudoscience
:: looks like science, but doesn't play by rule

how to properly evaluate a study?

: correlation and dependence
:: is there real causality?
: untested (*post hoc*) hypotheses
:: *p*-hacking, HARKing

: statistics

how to properly share knowledge?

: presentation
:: adequacy, brevity, factuality, interestingness

: logic, rhetoric & literacy

knowledge (state) = **cognition** (process) + **piece of knowledge** (result)

vs **guess** – unclear

vs **opinion** – biased

vs **believing** – accepted

knowledge – testable
: reasonable assumption

: Diagoras of Melos
praying & drowned men
:: data relevance

: **sensual** – innate to all organisms (given by „mechanical“ arrangement)

: **non-rational** – insight, grasping (not an intellection; intuition)

: **rational** – innate to all intelligent organisms
(given by the analysis of causes and consequences; theory of mind)
:: **scientific** – methodical knowledge (given by using the research method)

: **extra-sensual** – Ψ (yet unknown senses)

every piece of knowledge **is always connected** to another pieces

bringing up a new knowledge
(induction)

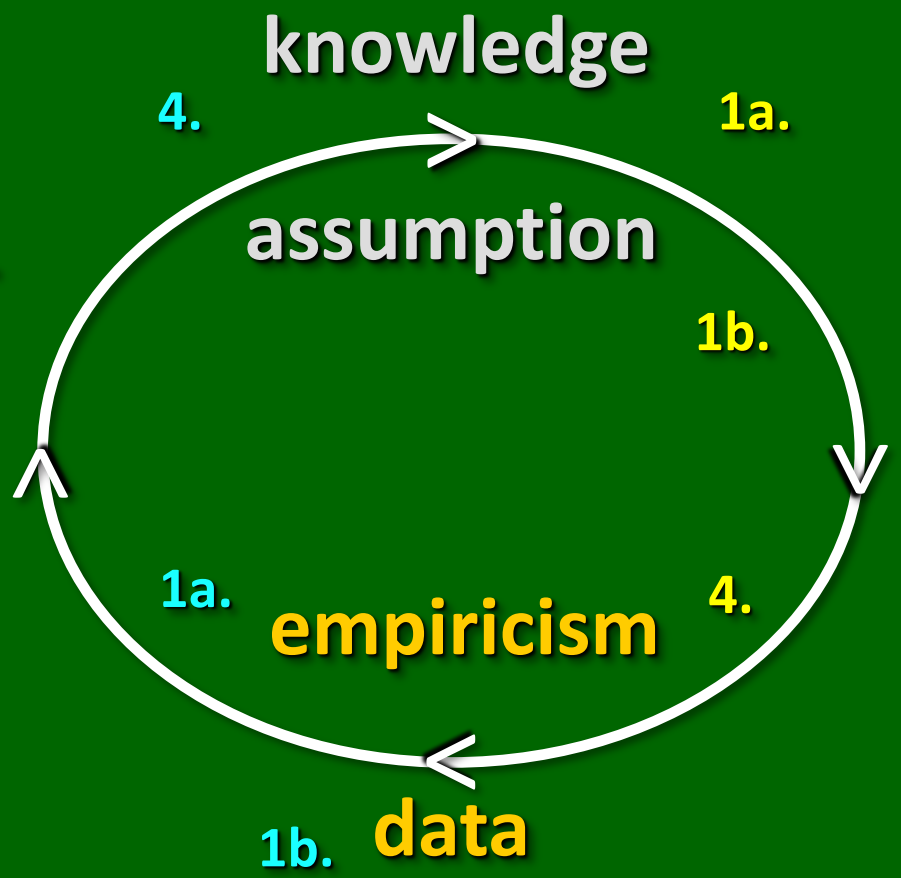
using

a composition of a solution
(synthesis)

inferring from knowledge
(deduction)

using

a decomposition of a problem
(analysis)



explication
3.

generalisation
2.

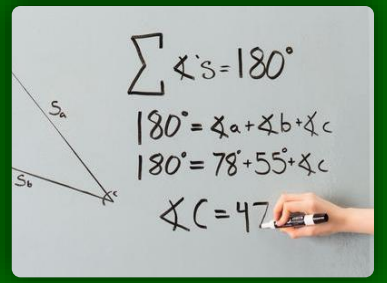
subdivision of a problem
2.

formulating a question
3.

analysis distinguishing of individual parts (of the system)
: from observable phenomenon to known

: **classification**

: **relational**

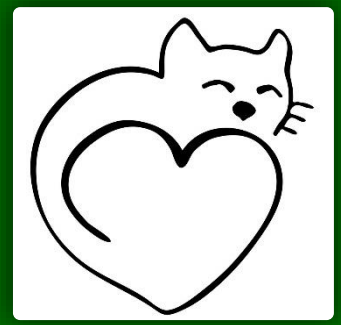


: **causal**

synthesis connection of signs & meanings of relevant system elements
: from known to unknown

: **abstraction**

:: approximation to the general from particular phenomenon



: **generalisation**

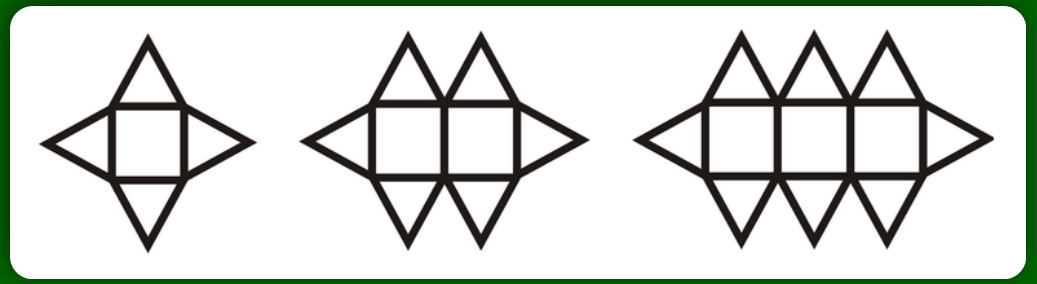
:: approximation of signs and relationships in a common picture

algorithm (obligatory) procedure of operation leading to a goal

: **scientific method**

induction *F. Bacon*

: argues from actual data to an inferred model
:: what's the general rule behind it?



P: whenever X then also Y (actual cases)
C: if X then Y (setting the rule; conclusion)

complete induction

: impossible in science
:: only in logic and mathematics

incomplete induction

inductive leap
we bridge it by testing

: leads to conclusion, even if we do not know all facts & elements
:: the conclusion is probable, but never sure – **inductive leap**

: properties of all the same phenomena in one set we study just by observing its subset, because we cannot study them all at once; it results in uncertainty of conlusions, ie. we make the leap

eliminative induction

method of similarity

if **A** precedes **X**, and is independent on others, we consider **A** to cause **X**

method of difference

if **A** precedes **X** and does not precede **non-X** while others are same, we consider **A** to cause **X**

method of joint rule of similarity and difference

if **A** precedes **X**, and **non-A** precedes **non-X** while others are same, we consider **A** to cause **X**

what are the necessary conditions to says it is sunrise or sunset?

... you know what i'm wondering about, master? every time you leave to check the guards, an order drops. is it not interesting?

this i'll tell you something even more interesting: whenever he does not leave to check the guards, no order ever drops ...

play *Blaník* (*Jára Cimrman*)

method concomitant variation

if $\mathbf{A_1}$ & $\mathbf{A_2}$ are cause of $\mathbf{X_1}$ & $\mathbf{X_2}$ and further $\mathbf{A_2}$ is cause of $\mathbf{X_2}$, then it applies that $\mathbf{A_1}$ is a cause of $\mathbf{X_1}$

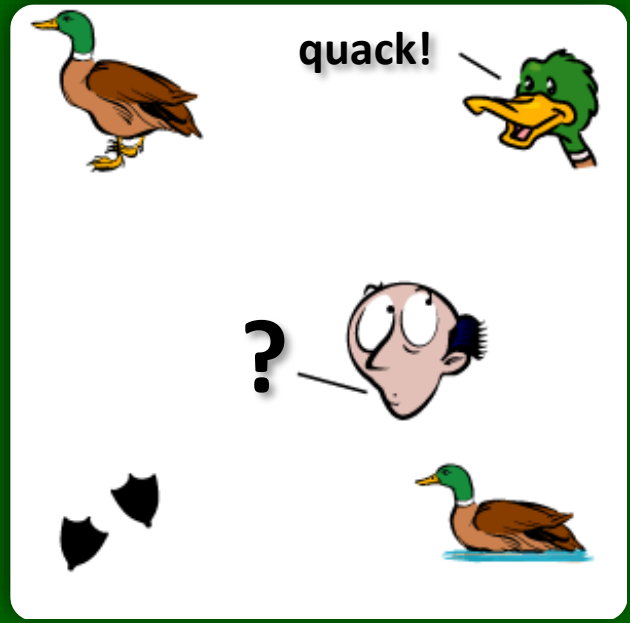
method of residuals

if $\mathbf{A_1}$ precedes $\mathbf{A_2}$ and we find that $\mathbf{A_1}$ causes partially (some components of) $\mathbf{A_2}$, then also $\mathbf{A_1}$ are cause of remaining components of $\mathbf{A_2}$

deduction

Aristoteles, Descartes

: argues from general principles to specific cases of expected data
:: general rule under the same conditions; true out of true



P1: if X then Y (general rule)
P2: X (actual case)
C: Y (conclusion)

natural deduction

rules are close to the intuitive, pre-logic thinking
: law of non-contradiction (X ≠ A ^ ⌐A)
: law of excluded middle (*tertium non datur*)
: law of identity (A = A)
: sufficient reason (trueness ~ reasoning; empiricism or derivation from true)

axiomatic deduction

axiom – it is not a true statement, only a good assumption
: consistence requirement (something is neither possible to verify nor falsify)
: independence requirement (cannot be guaranteed)
: completeness requirement (there is no final theory)

abduction

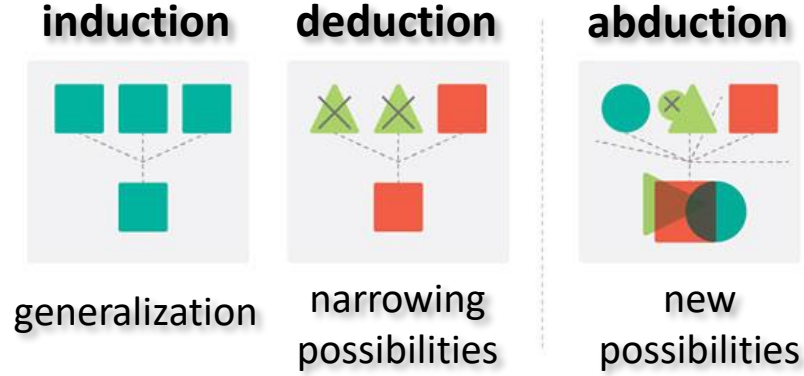
Peirce, Bateson

: argues directly from actual data to an inferred model
:: is the rule/model also the best explanation? supposed solution for *inductive leap*

P: Y (actual case)
C: if X then Y (belief revision / hypothesis generation)

: check if X (hypothesis test)

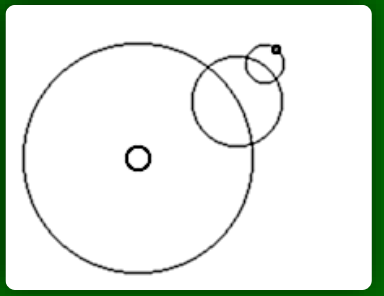
: sometimes used only to generate hypothesis / guess
: without the test, it is not necessarily reliable



deduction : derivation of *b* as a consequence of **a**
: guarantee of logical consistency

abduction : derivation of **a** as an explanation of **b**
: no guarantee of logical consistency

the most frequent method of defunct theory revision
: adaptation to a new finding; pitfalls of maintaining a lifeless theory
:: super-symmetry theory (weak and gravity forces paradox)
::: test did not show presumed consequences, adjust the original theory



: Hipparchus of Nicaea and epicycles

new finding might be inconsistent with current theory
: after abduction it is **consistently** incorporated in a frame of its principles

analogy

Lakoff, Johnson

ανάλογος – ratio

: argues about similarity of actual data to other data
:: similar phenomena should have similar rules

: cognitive process of **information transfer**

P1: if X ~ A and if Y ~ B (similarity of data)
P2: if X then Y (general rule)
C: if A then B (similarity of rules)

: different from deduction, induction & abduction
: no guarantee of logical consistency

identity of relation
: A is to B as C to **what**?
e.g. „hand is to palm as foot to ...?“

shared abstraction
: analogic objects share principle, template, regularity, attribute, effect or function
: described using comparison, metaphors or allegories

analogy = bad science, good pedagogy (*lies-to-children*)
: originally memetic principle of studying (authority copying)
: may be used to hypothesise, but not as a logical argument
:: Maxwell (physicalisation + mathematisation); electric current

how come there is intelligent life on Earth?

anthropic principle

example of abductive thinking

: in philosophy so-called **teleologic argument** (abductive)
:: out world is non-randomly ordered for us
::: Socrates, Thomas Aquinas, Isaac Newton...
::: William Paley (1802) – blind watchmaker
::: Frederick R. Tennant (1930) – philosophic teleology

: in physics and cosmology
:: 1961 – Robert Dicke
:: 1973 – Brandon Carter, term *anthropic principle*

: **non-random** constellation of natural laws **leading inevitably** to the creation of **man**
:: role of observer in quantum physics
::: observed seems to be influenced by observer

strong anthropic principle (*SAP*)
: natural laws are so, that it necessarily leads to origin of life

weak anthropic principle (*WAP*)
: natural laws need to be so, that they are compatible with origin of life

(S)AP is often used as **an argument** for an existence **intelligent designer**

: idea of **fine tuning** of natural laws
  :: principle of **emergence** disproves it
  :: it seems, that „main“ constants are not so constant
    ::: fine structure constant seems to change with time
: results from **teleological & social** point of view (system 1)
  :: humans do things intentionally & tend to see intent in causal chains

AP – **logical tautology** (circular reasoning, begging the question)

AP is not a testable scientific hypothesis
: AP is used to derive e.g. prediction that there is no non-C life in universe
  :: this cannot test AP – it is neither disprovable, nor justifiable

... if AP applies, then wieners have their slim and long shape to fit a bun ...
Stephen J. Gold

what is **cause** & what is **consequence**?
: cognitive trap causing wrong analysis of data

basic physical constants
: arbitrary numbers
:: not derived theoretically, but empirically

$$F_g = G \cdot \frac{m_1 \cdot m_2}{r^2}$$

adaptation
: natural selection
:: variability and selection pressure

absence of aim/goal/purpose
: polar bear did not receive a fur not to freeze
: that bear did not freeze to death, who had a better fur

scientists sometimes hypothesising **assume an aim/goal/purpose**
: although especially in cosmology and biology they should not
: question remains, what in fact **aim/goal/purpose is**

: **thinking**, we often **use teleological point of view**
:: it is cognitive function
::: e.g. term *selfish gene*

hypothesis – knowledge searching
: requires theory for formulation
theory – knowledge generalisation
: theory is an undisproved hypothesis

a way we ask questions in science

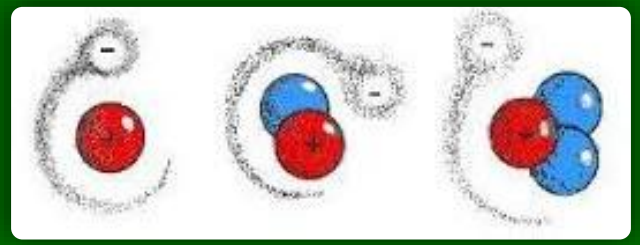
hypothesis

ὑπόθεσις – assumption, basic

hypothesis types (basic)

general hypothesis

: **for any X there is Y**
(∀X∈M: if X then Y)
:: unverifiable
::: practically impossible to investigate all cases
:: falsifiable / infirmable



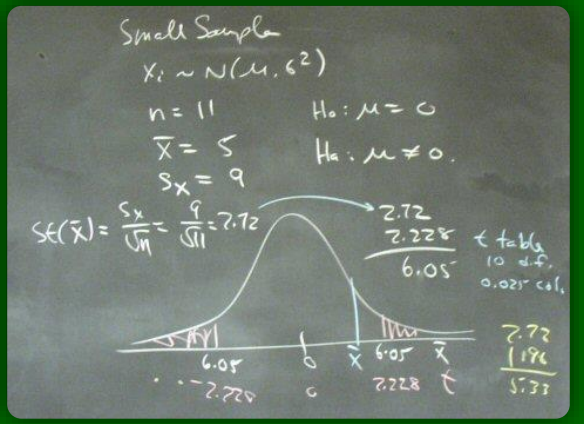
particular hypothesis

: **for at least one X, there is Y**
(∃X∈M: if X then Y)
:: verifiable
:: unfalsifiable / confirmable
::: similarly as within the general one

in science, mostly just type one hypothesis appears
: **all its consequences** are tested for conformity with reality
: **one contradiction** is enough to **reformulate** the hypothesis

scientific (meta)**hypothesis** : set of hypotheses (propositions)

mathematics – „weird“ science; proofs of propositions (Gödel)



in science, there is nothing certain!

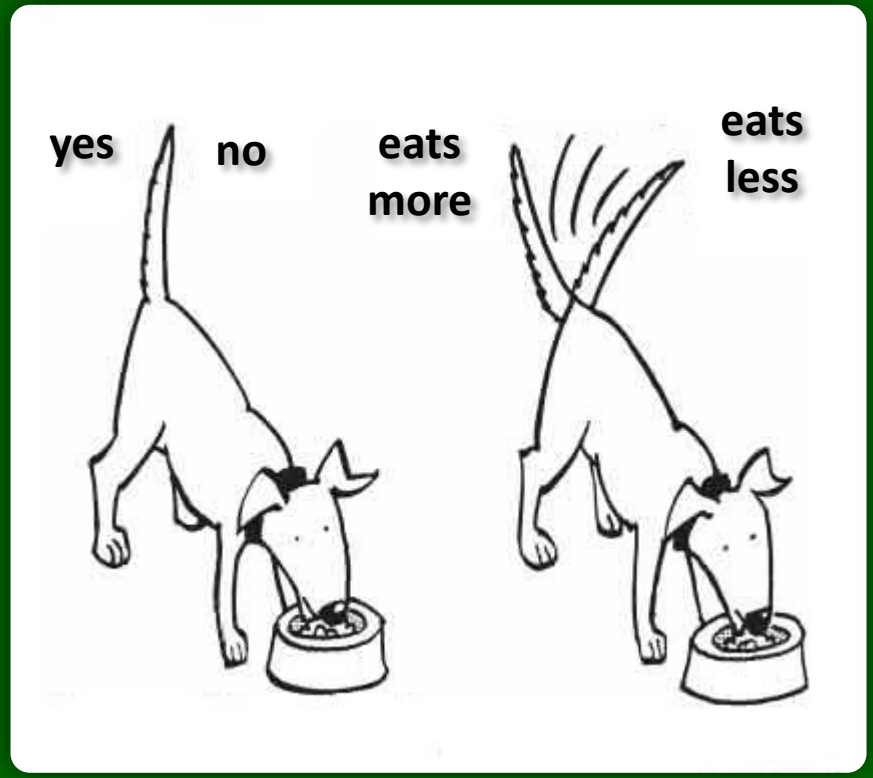
uncertainty is a function in science, not a defect!

what could the question in hypothesis be casted?

what is the relation between food in-take and mood within dogs?

does the happy dog eat more?

how does mood influence a canine behaviour?



hypothesis

one-tailed

two-tailed

new hypothesis / premise

: testable (infirmable / confirmable)
:: based on repeatedly observable / testable phenomenon
:: we can determine the conditions of its validity & the conditions of its invalidity

: consistent
:: contains all the parts necessary for explanation & doesn't these mutually contradictory
:: in the paradigm frame – revolution in science, yes, but not at all costs

: economic
:: does not contain superfluous parts
:: Ockham's razor; not necessarily correct, but the best starting point

: extending & useful
:: it should refine or shift the previous pieces of knowledge
:: it should serve the prediction beyond the frame of hypothesis

: it's turtles all the way down

speculation – basics of premise
: if i assume that X applies, may i use it to construct a hypothesis?

additional (*ad hoc*) hypotheses

ad hoc – up to it

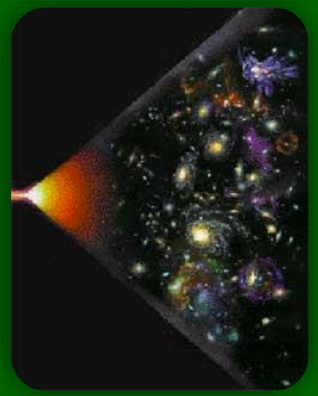
big *ad hoc* hypothesis

: additional hypothesis (in reformulating) tending to explain the disproval of the original one

: it is not really a logical fail, it is rather a proof of evidence bias

:: irrational reluctance to reformulate the original one instead of mere improbable modification

: alien abduction



: Einstein & cosmologic constant

small *ad hoc* hypothesis

: additional hypothesis (in reformulating) explaining one unexpected aspect of observation

: again, it is not really a logical fail

:: it is suspicious as it may blur the wider context resulting from unexpected consequences

:: synergy of hypotheses – e.g. third Kepler law

: where the neutrino came from

: dinosaurs hidden in the cave

types of working hypotheses

alternative hypothesis (H_a)
: dependence between studied variables

null hypothesis (H_0)
: no dependence between studied variables

testing H_0 /statistical test (test of significance)/

: we presume that hypothesis H_0 is valid ☺
:: **neutral**, **unbiased** approach; minimisation of cognitive biases
:: without hypothesis, science makes no sense – false positive results

: we decide using which **random experiment** we shall test the hypothesis
: we assign which **random quantity** should be the result of the test

random experiment
: its result should not be conclusively predictable from the conditions
: it must be indefinitely repeatable under the same conditions

random quantity
: variable which value is conclusively given by result of the random experiment

example of null hypothesis formulation

: assumption – effect A is stronger than effect B
:: H_0 – average values of random quantity of effect A and B are equal
: assumption – effect A is under Q stronger than under Z
:: H_0 – average values of random quantity of A are under Q and Z equal
: assumption – the stronger effect A, the lower value B
:: H_0 – average values of random quantity of B is equal under different values of effect A

null hypothesis testing

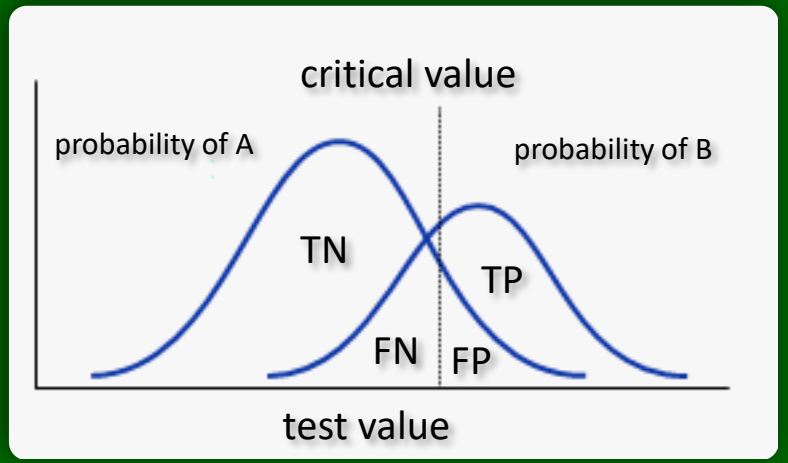
: formulating (frequentist/Bayesian) **statistical assumption** of the test
:: e.g. nature of studied sample, independence of independent variables, values distribution
: defining **statistical test**, which will be suitable under given circumstances
:: most often used tests – Student t-test, ANOVA, χ^2 test, …
: deriving what **test statistics T** should be under chosen assumptions
:: **test statistics T –** function, which gives, if H_0 is valid, how probable are the measured data

: **test *p*-value** (*p-value*)
:: probability that with H_0 valid, the test statistics T would be of a value out of interval <−T,T>
: **test confidence level α**
:: a number chosen in interval 0 to 1 (0 – 100 %), the lower, the better, usually 0.05
:: **risk level**, that H_0 **will be incorrectly rejected**, although it is valid (consideration of **inductive leap**)
:: defines so-called **critical region**
::: **such a part** of region of possible values of used random quantity, into which **the quantity result falls** with probability **α** once H_0 is valid
: if then **p < α**, validity of H_0 has very low probability
:: result of a random quantity measurement fell into the critical region – **H_0 rejection**, **H_a acceptance**

: accepting hypothesis H_0 means that we consider it **possible**
: rejecting (*falsifying*) hypothesis H_0 is equivalent to **accepting** *corroborating*) hypothesis H_a
:: i.e. observed relations are not by chance

errors in testing

: error type I (false positive results, FP)
:: rejecting H_0, although it is valid
: error type II (false negative results, FN)
:: accepting H_0, although it is invalid



simple case of hypothesis testing

: scientist Henry decides to test if psychics can communicate with the beyond

:: Henry will ask YES/NO questions to which the psychic cannot possibly know the answer, but he could get them communicating with the deceased

::: ***p*** is the probability that the psychic will answer ***n*** of his questions correctly $\mathbf{p = \frac{1}{2^n}}$

::: Henry chooses to accept that the psychic is communicating with the beyond if the probability that the psychic answers all questions correctly is less than 0.1% (**α**)

:::: Henry tries hard to exclude that psychic answers them randomly correct

:::: he calculates that the medium would have to answer 10 questions correctly $\mathbf{0.001 < \frac{1}{2^{10}}}$

:::: if the psychic can do this, it is probably communicating with the beyond (but it is not for sure)

p-hacking
data fishing (data dredging, data snooping)
doi 10.1038/506150a

: *if you torture your data enough, they'll eventually confess*
: or search for statistically significant patterns in data, but without hypothesis
:: this is not true testing, does not produce relevant conclusions
:: allows to formulate hypothesis, but it should be tested with new data
:: ends mostly with publishing false positive results

the scientist decided to experimentally study one phenomenon (dependence). the first study design did not work as expected, but the scientist modified the experimental procedures and conducted the second study. it looked more promising, but still did not give $p < 0.05$ after data analysis.

the scientist, convinced that he is on track, is collecting additional data. he decided to exclude few results that looked clearly off. then he noticed that one of his adjustments to the procedure gave a clearer picture and therefore focused on it. a few improvements to the procedure and the scientist finally identifies a slightly surprising but really interesting dependence that reaches $p < 0.05$. the scientist stubbornly tried to find such a dependence, knowing it was hiding somewhere. he also felt the pressure to reach the desired p-value.

but there is a catch.
in fact, there was no such dependence. despite a statistically significant result, the scientist published a false positive result.
the scientist felt that he was using his scientific insight to reveal the hidden phenomenon when he took various steps after he started his studies: he collected more data. he excluded some data that looked off. he abandoned his failed attempts and focused on the most promising. he analysed the data a little differently and made some more tuning.
in fact, he worked methodically incorrectly, unscientifically because he did not fully understand the scientific method.

: methodologically wrong and ethically dubious research
: considered to be the cause of the **replication crisis**
:: published dependence does not exist *de facto*, the study cannot be repeated

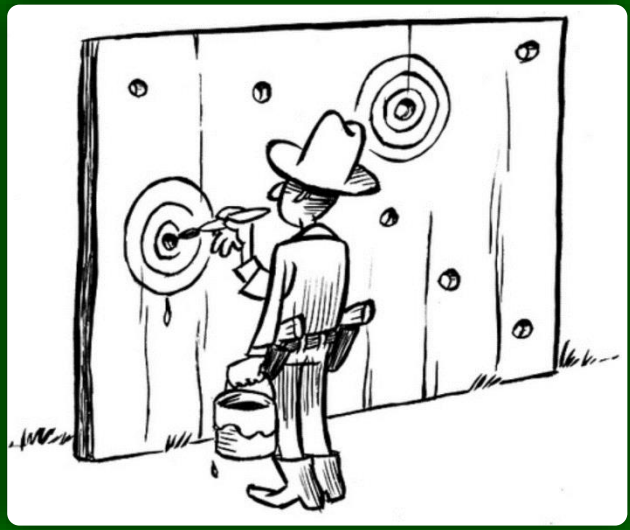
how to deal with it?
: instead of calculating *p*, the **estimation statistics** or **bayesian approaches** are better
:: the first uses confidence interval, data meta-analysis and effect size analysis
:: the latter then conditional probabilities and interprets probability of original hypothesis
: pre-registration of the study (e.g. at OSF.io) and subsequent publication of the procedure
:: monitoring of the correctness of the study progress

HARKing (hypothesising after the results are known)

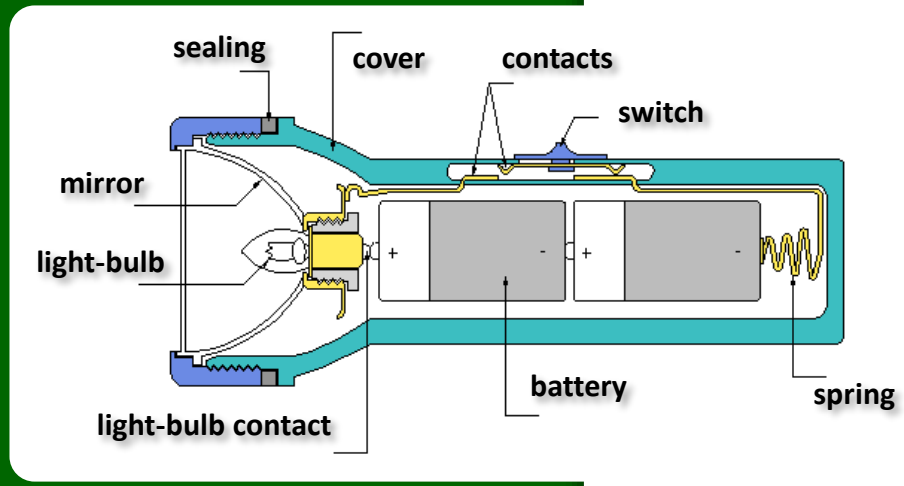
doi 10.1207/s15327957pspr0203_4

: formulating *a priori* hypothesis after *de facto* testing this hypothesis
:: *post hoc* hypotheses formulated based on data tests, pretending to be original hypotheses
:: denying a disproved *a priori* hypothesis
: from the outside it seems that all *a priori* hypotheses are proven and none are refuted
:: the effect of the hunt on positive results
:: considered to be the cause of the **replication crisis**
: the solution is to change the culture of the publication and the severity test
:: strict type I error checks, statistical power analysis, correct random experiment

a texan sharpshooter aims and fires his gun at target on a barn wall but misses. he then walks up to the wall, rubs out the initial target, and draws a second target around his bullet hole in order to make it appear as if he is a good shot.



A reader quick, keen, and leery
Did wonder, ponder, and query
When results clean and tight
Fit predictions just right
If the data preceded the theory



phenomenon

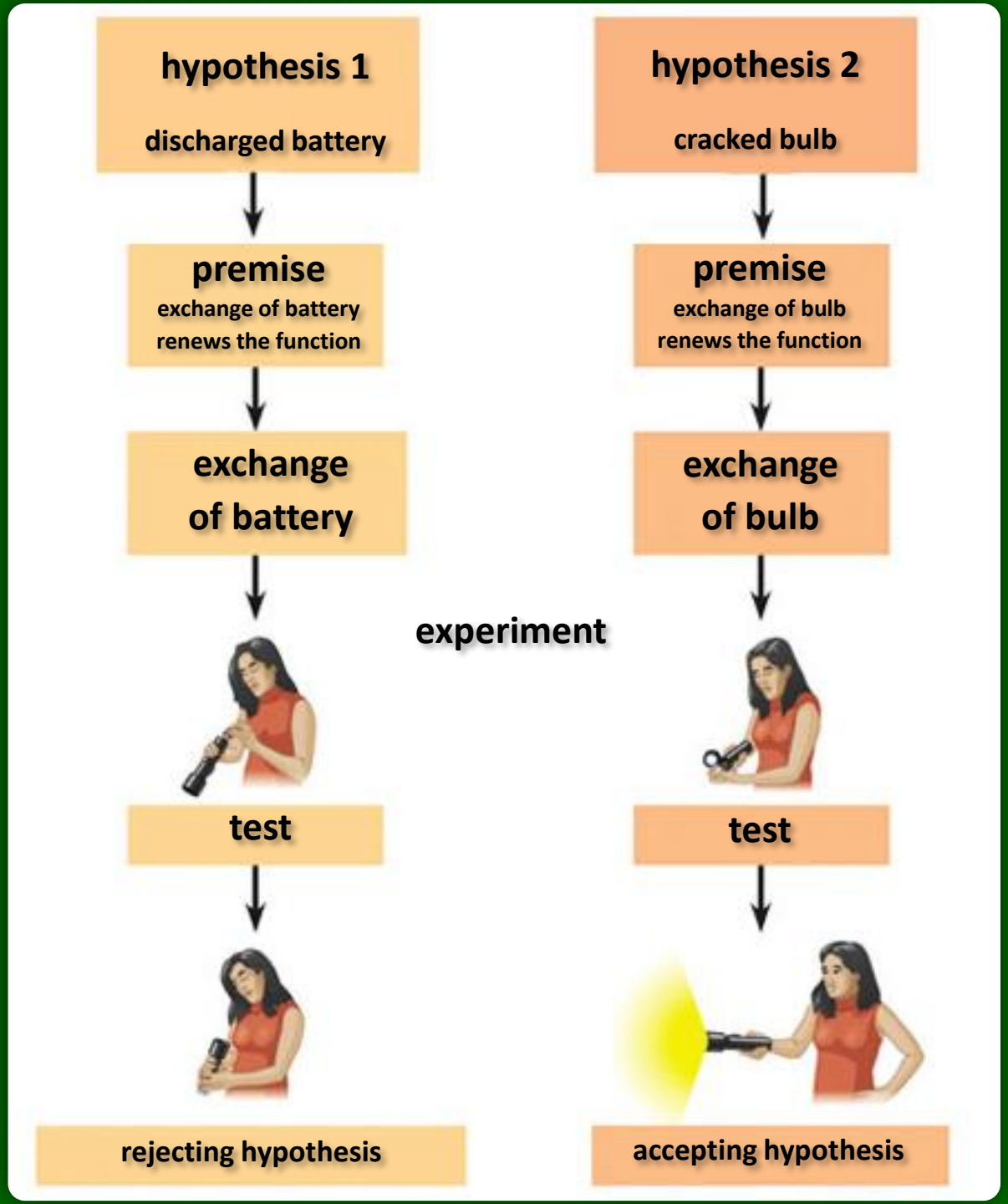
questions

hypothesis 1

discharged battery

hypothesis 2

cracked bulb


hypothesis 1
discharged battery
premise
exchange of battery
renews the function
exchange
of battery
test
rejecting hypothesis
experiment
hypothesis 2
cracked bulb
premise
exchange of bulb
renews the function
exchange
of bulb
test
accepting hypothesis

phenomenon → **hypothesis** → **prediction**

: reformulation of hypothesis
without consequent test
:: *ad hoc* hypotheses

reformulation of hypothesis

inconsistent

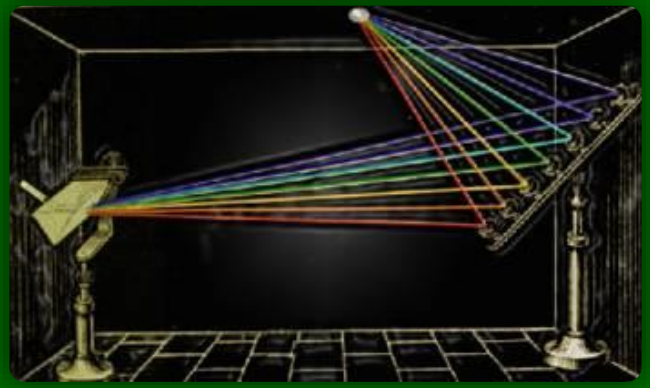
empirical test

consistent

meta-hypothesis

theory

paradigm



Ignaz Philipp Semmelweis
: physician, maternity ward, obstetrics

ReaLife science
hypothesising in praxis
with the social consequencies

situation
: childbed fever (*febris puerperalis*)
:: known since antique
:: caused *ca* 20 % of postnatal deaths of mothers
::: worsened after institutionalised child births in hospitals

observation
: higher mortality in hospital department, where medics-students assisted
: lower mortality with mothers giving birth prior to hospitalisation

hypothesis
: some agent from the dead bodies is the cause
:: students came to the ward directly from dissection exercises
::: recent cases of physicians dying due to injuries during dissections
: thorough hygiene may solve the problem (removing the agent from hands)
:: tested by one group having hands washed with calcium hypochlorite
::: **decrease of the infection** frequency in one order of magnitude
::: **further decrease** of general infections after tools sterilisation

scientific aspects

: Semmelweis was not exactly a good scientist

:: contemporary accepted explanations – *dyscrasia* (bad humours), *miasma* (bad air)

::: semi-empirical galenic observations with no testing at all

:: he did not conduct his study systematically and also did not present it properly

::: he used proper time series rate diagrams, but not systematically

::: he wrote no research paper, he just wrote letters to hospital directors

:::: thus he met opposition due to unconvincing scientific study

:: he cannot offer an explanation

::: not his fault, the theory behind microbial infection was not yet fully formulated

:::: another 20 years were necessary

social aspects

: strong opposition despite immediate improvement (< 2 % cases thereafter)

:: physicians refused the responsibility that they might be the problem

::: physician-gentleman cannot be unclean

:::: washing hands was a social status offence

::: suicides among young physicians, Semmelweis himself collapsed

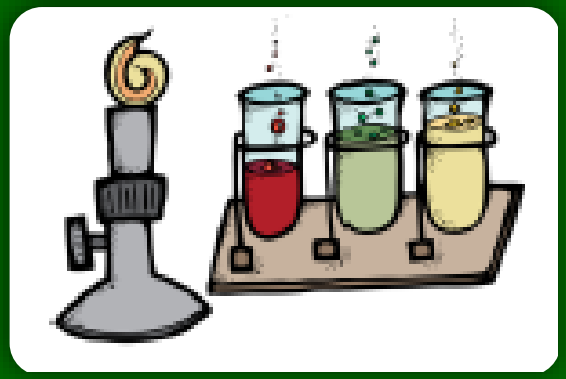
::: slow progress in implementation of the thorough hygiene (see Max Planck progress principle)

scientific method

: distinguishing the repeatable **phenomenon from random** (noise)
:: we try to find something studiable (we describe)

: evidence for relations amid **such a phenomenon** & **circumstances** under which it occurs
:: we search for causative relations
::: we search for dependencies (attention, these are not correlations)

: generalising the relations & **predicting related**, but **yet unobserved phenomenon**
:: formalising the relations found and drawing of consequences
::: i.e. what has to happen, if it is so
:: generalising the found relationships carries with it the danger of the **inductive leap**



: test the prediction
:: minimisation of **inductive leap**
:: in fact we **justify** or **falsify the generalisation**
:: if justified, the generalisation means **a new piece of knowledge**
::: nevertheless, **evidence is not a proof**

science
what it might be?

science embodies

: **objectivity**
:: repeatable phenomena, no personal preferences

: **criticality**
:: sceptical & critical evaluation, anything can be questioned

: **testability**
:: specific ways of empirical testing
:: consequentially so-called **self-correction effects**

: **autonomy**
:: maximum independence
::: problematic – social, financial and industrial

: **advancement**
:: allows cumulative knowledge

...and what it is not

set of **verified pieces of knowledge**
: but (methodically) **organised**
:: inductive leap consequrnce

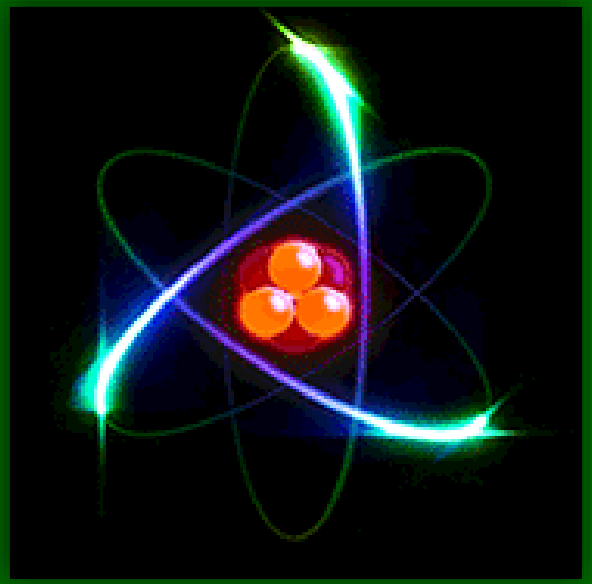
: phlogiston

it is always possible to argue **HOW**,
but not (or only rarely) **WHAT**

: combustion

goal of science should be acquiring general knowledge on observable

i.e. using **scientific method to model the observable world**
: by means of natural laws (models)



realism

to provide true theories about our world
: problem of **agnosticism** (e.g. deterministic chaos, quantum phenomena)

instrumentalism

to provide functional models of observable for predictions
: **useful fictions** (e.g. equator, electric charge...)

reality and **truth**

reality
: objective reality – independent of our mind/senses
:: but without this assumption, science makes no sense

: intersubjective reality
:: dependent of our minds

truth
: unreachable
:: due to unreachable objective reality

paradigm

παράδειγμα – template, example, model

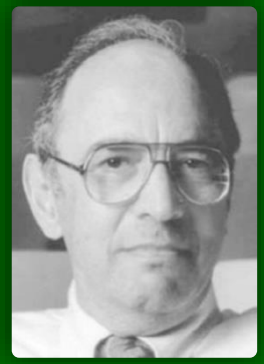
discourse, hard core

continual or discontinual increase of knowledge?

Kuhn model – incommensurable paradigms

: knowledge development – normal science > crisis science > revolutionary science

: paradigms are exclusive



Lakatos model – scientific research programmes

: research programme is broader than paradigm

:: programmes may coexist and compete

:: programmes evolve in times

::: **hard core** (axioms) stays, **protective belt** (heuristics) changes

Laudan model – research traditions

: research tradition is also broader than paradigm

:: traditions may coexist and compete

:: much looser connections in-between them

:: **acceptance** (belief in trueness) or **pursuit** (deciding if to accept a tradition)

:: pursuit the one with actual highest measure of ability to solve problems

new theory does not win through **trueness**, but **plainness**
: even the old theory could explicate *: Aristotle and gravity*
:: difficulty to accept new theory due to cognitive biases
:: supporters of the old one **must die** out or **retire**
::: so-called Max Planck progress principle – *science progresses funeral by funeral*

discoveries must be done **several times** (many times), until the scientific **community notices** them

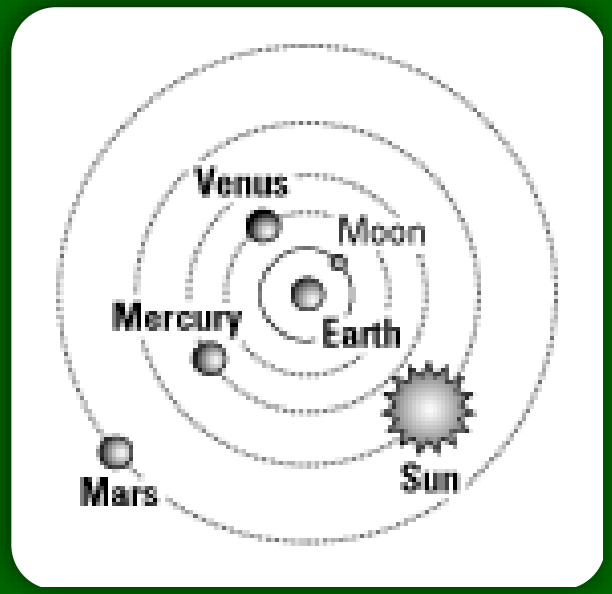
: John J. Waterston

: theory **is** a set of (meta)hypothesis, **not** better evidenced hypothesis
:: they change in time
::: **hard core** stays, **protective bolt** is changed

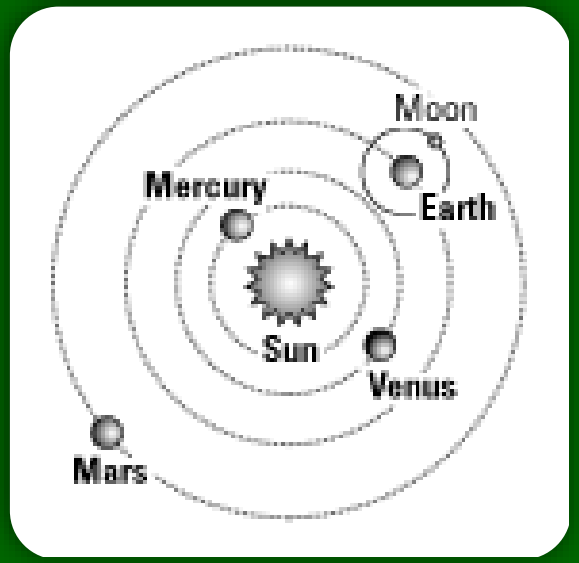
: theories **cannot be proven**, but should be **disprovable**
:: within **high** level of complexity, they **cannot be even disproved**

: **premise on theory validity** (which no one tests)
:: which is not even known or is just too obvious

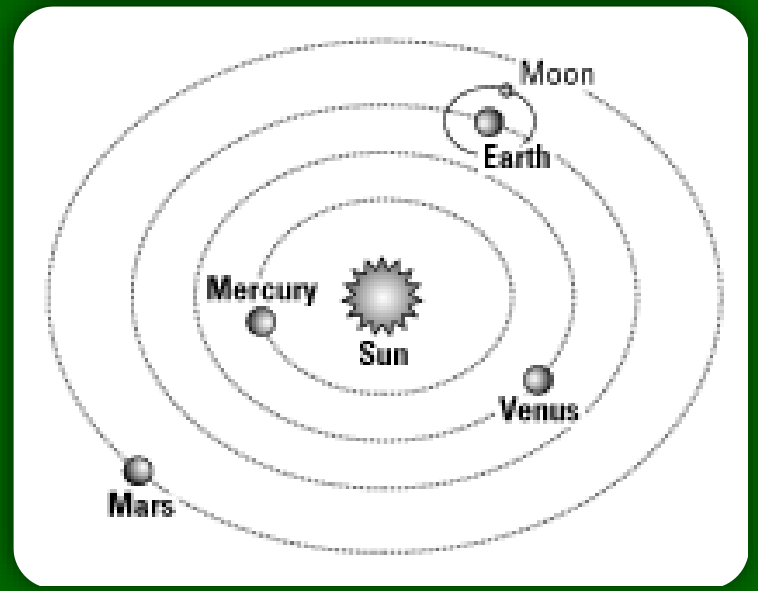
: science easily survives a (**black boxes**) a do not cause chaos
: it is good to **orientate one-self in science** one „floor“ up and down
: popularisation is a tool to keep **historical scientific memory**



Ptolemaic model
: was imprecise, but sufficient



Copernican model
: not much more precise, but simpler
:: Brahean hybrid model



Keplerian model
: explains much more
:: Venus phase

Aristarchus vs **Ptolemy** vs **Copernicus** vs **Brahe** vs **Kepler**

: different descriptions of the same

:: Aristarchus heliocentric model

::: it was widely accepted, but definitely failed

:::: no convincing evidence and later also the lack of will (religion)

plus no pressure to make it more precise

:: Ptolemaic model

::: *Alphonsine Tables* 1252; precision ≥ 1° → **unreliable predictions**

:: Copernican model

::: *Prutenic Tables* 1551; precision ≥ 10’ → **also not much unreliable predictions**

:: Brahe-Kepler

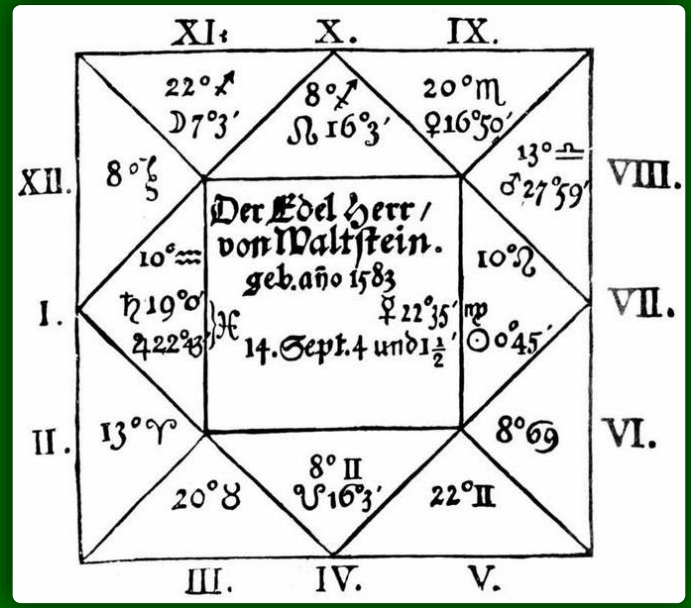
::: *Rudolphine Tables* 1627; precision ≤ 1’→ **precise measurements gave predictions for ± 200 years**

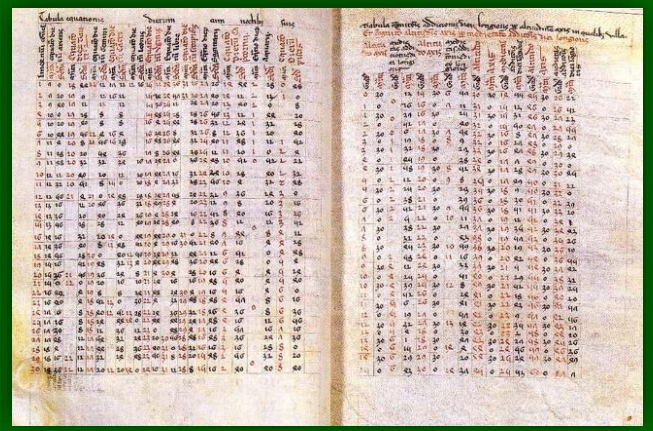
::: Brahe (♁ central, rest revolves ⊙)

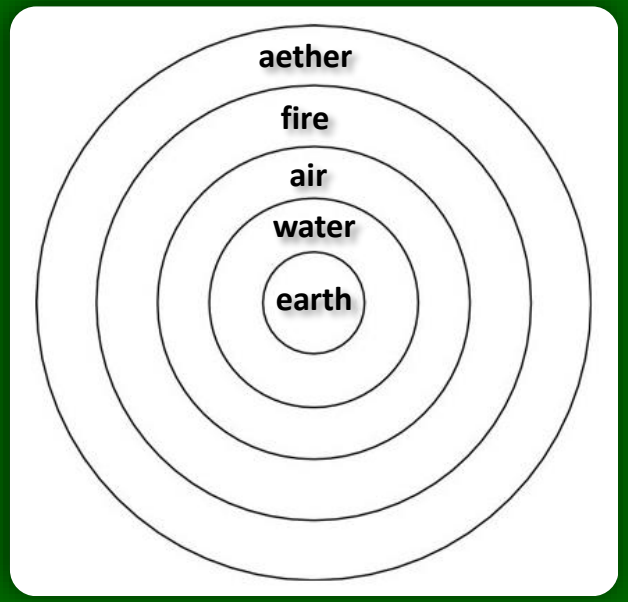
:::: he still hopes to save old teachings

::: Kepler

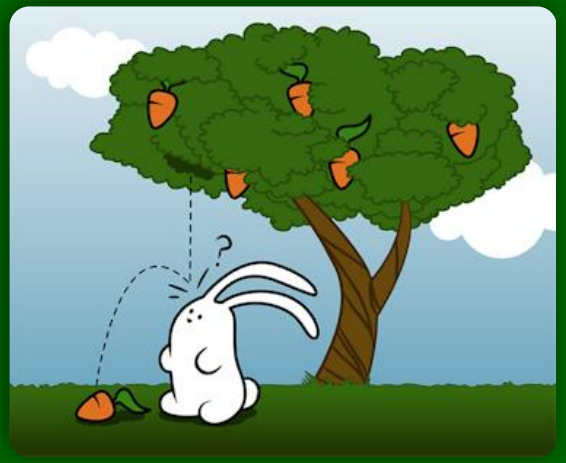
:::: correction of Copernicus – elliptic instead of circular orbits







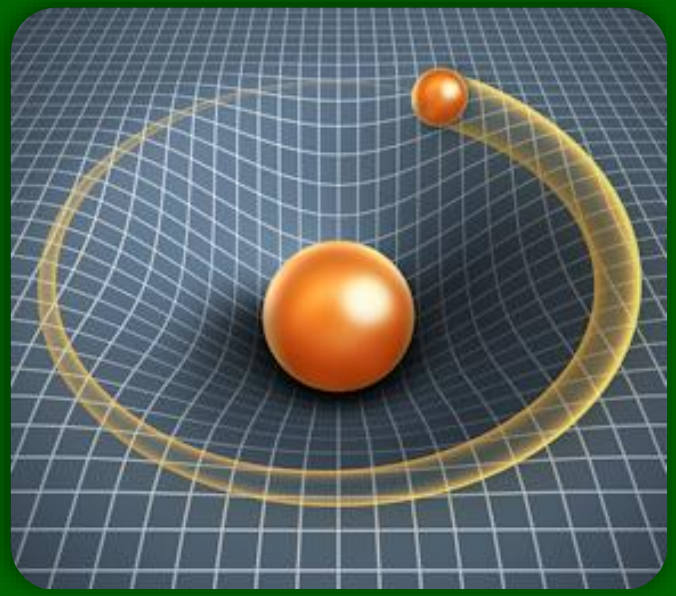
why do objects fall towards the ground?



Aristotle (– 4th cc) – tópos (*τόπος*)
: things search for their natural place
:: universe is arranged in levels
:: object is attracted to the level of its substance

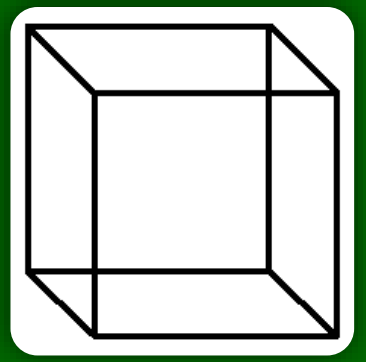
Newton (17th cc) – (attractive) force
: law describing dependence of the force on mass and distance

$$F_g = G \cdot \frac{m_1 \cdot m_2}{r^2}$$



Einstein (20th cc) – folded space-time
: law describing the force as space-time curvature

$$R_{\mu\nu} - \frac{1}{2} \cdot R \cdot g_{\mu\nu} + \Lambda \cdot g_{\mu\nu} = \frac{8\pi \cdot G}{c^4} \cdot T_{\mu\nu}$$



confusing changes in knowledge paradigm

: scientific models of reality take place out of our everyday experience
:: they change relatively fast and the level of understanding by laymen too

neurophysiology, cognitive psychology; physics of elementary particles

any sufficiently advanced technology is indistinguishable from magic
A. C. Clarke

any technology that does not appear magical is insufficiently advanced
G. Benford

basic methodical limitations of science

: cognitive biases
:: we are prone to **erroneous decisions due to how our mind works** (system 1 vs system 2)

: inductive leap
:: **observations**, from which we **derive the general rules** are **never complete**
:: natural (general) laws **could not be thus proved**, only eventually **disproved** or **evidenced**

precision of measurement is controlled by our **requirements for prediction**
: there is **no absolute precision in any measurement**
:: complex model takes too much time making the problem solution impractical
:: simpler approximation takes less time and makes problem solvable

: mass of Earth
: quantum chemistry

scientists for the sake of practicality **neglect the marginal** (Ockham's razor)
: it is a **voluntary** restriction
: may be **erroneous**, but can be **tested**

empirical tests should not be done only **well**, but also **correctly**

science is not so much **a search for truth** as it is **a refutation of errors**

Alexander Calandra &
a story with barometer

argumentation

how do we communicate knowledge?

how does language and culture influences it?

: cultural influence
:: metaphors
:: mysticism & secrecy vs. rationalism & openness
: language influence
:: language with social prestige
::: Latin, French, German, English

: strong cultural context
:: may be blinding and hindering

how does the attention influences the information?

: people like exciting stories more than truth
:: media meet that tendency
: critical reading is a tool which needs learning and practice

: how to recognise a proper medium?

how do we do support our conclusions?

how do we convince recipient about our conclusions?

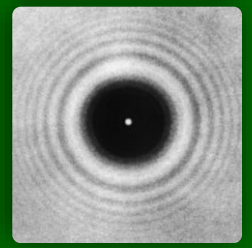
: formal logic
:: unambiguous chain of logical statements
: burden of proof
:: ze who states something is responsible for the proof
: absence of emotion oriented appeals
:: argumentation fallacies
::: hasty or sweeping generalisation
::: *non sequitur* or *post hoc ergo propter hoc*
::: *ad hominem* or *ad baculum*
::: false analogy
::: false dilemma
::: red herring
::: straw man
::: bandwagon appeal

: our argumentation is as strong as the weakest statement

science – a way to acquire **a reliable** and **correct** knowledge on phenomenon – there is **no universal one**

knowledge = quality data + logical & convincing presentation

how do we recognise **reliability** of the piece of knowledge?



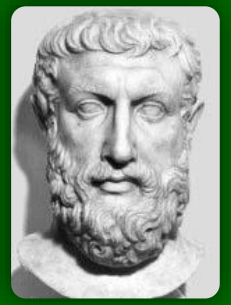
: Fresnel, Poisson & Arago
:: wave theory of light

: Piazzi, Gauss, Zach/Olbers
:: dwarf planet Ceres

: **prediction from theory (*theoretical approach*)**
:: (empiricism) → theory → empirical test of unexpected consequence

: **prediction from empiricism (*empirical approach*)**
:: empiricism → theory → empirical test of expected consequence

: Thales of Miletus & the battle of Halys 585 B.C.E.
:: eclipse prediction supposedly allowed Lydians to win war



: **falsification** (infirmation) of the actual model/paradigm
: **justification** of the actual model/paradigm

how do we recognise **correctness** of the piece of knowledge?

: strong inference
: sorting of alternative hypotheses
: use of alternative decision making (two independent methods)
: unsuccessful attempt of model falsification/disproval

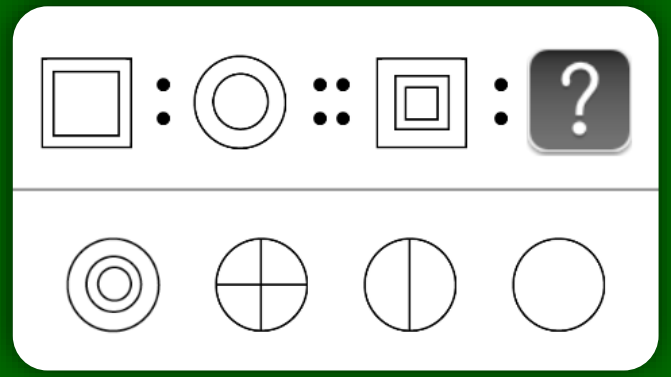
in experimental sciences, **direct way** from facts to conclusions does not always exist

why? → insufficient information (incomplete information), novelty

heuristic procedure
: trial search for solutions
:: trial & error approach

reductive judgement
: not logically valid, but acceptable probabilistically
:: in science, there are no irrevocable proofs

inductive judgement
: not logically valid, but acceptable probabilistically



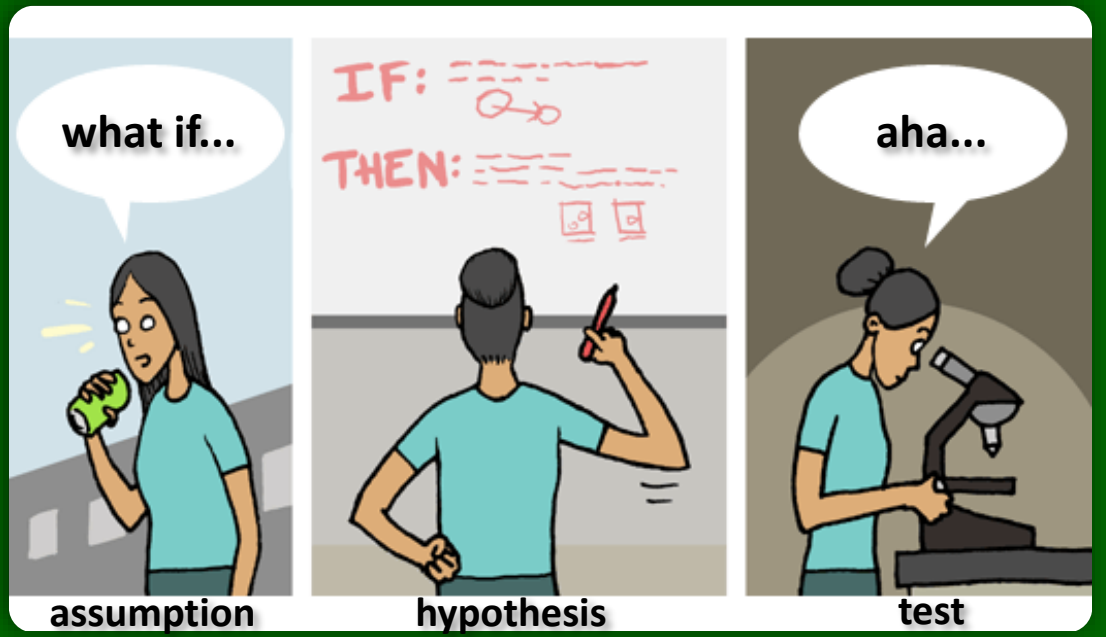
analogic judgement
: not logically valid

basics of argumentation (reasoning)

... if it was so, it might be; and if it were so, it would be; but as it isn't, it ain't ...

Lewis Carroll, *Alice in Wonderland and Through the Looking-Glass*

argumentation is a part of **evidence**
: facts and their interpretation



argumentation or **reasoning**
: a way to convince others about our claims
:: not necessarily true ones 😉
: a way to defend your position
: a way to question or refute position you find questionable

argument and its parts

statement
: is a claim, which may be **true** or **false**
:: **imperative**, **appeal** or **questions** are not statements

argument
: set of statements following **a conclusion**, final judgement

: **relevance** – evidence should support claim
: **representativeness** – not just one-sided opinion
: **sufficiency** – enough evidence, not sporadic one
: **accuracy** – precise, accurate and up-to-date data (evidence)

statement classification

: **verifiable**
:: qualified by experiment or credible source
: **evaluable**
:: includes taste or demand interpretation

: **specific**
:: exact numbers
: **unspecific**
:: inexact numbers; easily interchangeable for specific

vagueness
: not clear in given context

ambiguous
: at least two meanings in given context

logical analysis of arguments

composed of two parts
: **premise** (P)
:: one of the premises is a statement (P1)
:: one of the premises is a rule (P2)
::: arises inductively
: **conclusion** (C)

P1: it rains
P2: when it rains, then it is wet
C: (therefore) it is wet

purely deductive reasoning
: logically valid
: trueness of P guarantees trueness of C

: deductively invalid
:: no unambiguous conclusion
::: the rule is missing
::: trueness of P does not guarantee trueness of C

P1: i dropped a bottle of beer
C: (therefore) the bottle broke

P: i dropped a bottle of beer
C: (it is the reason for the fact that) the bottle broke

inductive reasoning
: comes from experience
:: basis for conditional premise

P1: when a bottle hits the concrete, it brakes
P2: when a bottle hits the stone, it brakes
...

a valid argument – *measure of form*

: corresponds to rules for deductive constructions

:: conclusion results from premises

: invalid argument doesn't necessarily result from premises

: need not to be necessarily true

P1: it snows
P2: if it snows, cats speak
C: thus cats speak

a true argument – *measure of content*

: premises are true statements

P1: all cats are animals
P2: some cats are black
C: thus some things black are animals

a sound argument is **formally** & **contentually** correct

is this a valid, true or sound argument?

P1: Arrhenius supported eugenics
P2: Arrhenius warned against global warming
C: thus all who support idea of global warming are also supporters of eugenics

the burden of proof (*onus probandi*)
: the one who tells, not an opponent

Ockham's razor
: a less complex solution is more probable

Hume's razor
: a lie is more probable than a miracle

Hitchen's razor
: a claim without proof can be without proof dismissed

Popper's razor
: hypotheses are scientific if they can be disproved

correct argumentation
– i have a can of beer.
– really? prove it.
– yes, here it is.
– ah, you're right.

incorrect argumentation
– i have a can of beer.
– really? prove it.
– ha, prove that i don't!
– wtf?

non-existence of evidence is not proof of non-existence
: but you can't prove non-existence anyway

: immigrants do not want to work and they take our jobs

contradiction : both statements cannot be true, but also not untrue (negation test)
possibility : both statements could be true and also untrue
conflict : both statements cannot be true, but could be both untrue

: this dog is white and black

: inside the globe there is another globe much bigger than the outer one

statement evidence

searching for **obviously true** statements (empiric support)
+ already **supported statements** (literary research)
: we cannot repeat the whole history of science

evidence process – logical judgement chain

statements (appeals)

logical appeals

: on sense of reason; targets system 2
:: not only evidence, but interpretation makes the cause stronger
: sets the credibility of topic, and thus of disputants

scientist
A correlates w/ B (p = 0.56), under C, D & E

university PR
under certain conditions
there is a relation between A & B

journalists
A causes B, say scientists

conspiracy theorists
A is dangerous and can kill us

emotional appeals

: on feelings and instincts; targets system 1
:: unconscious reactions – dangerous
: sets the credibility of disputants

social/ethical appeals

: on a sense for right and wrong; targets both systems, but mainly system 1
:: again, unconscious reactions of system 1 make it dangerous
: sets the credibility of disputants

hasty generalization
: claim made on inadequate evidence
:: *youngsters reading violent books are violent, so ban the books*

sweeping generalization
: claim made on absolute statement
:: *all man are obscene*

post hoc ergo propter hoc (after this, therefore because of this)
: claim made on just one thing preceded other
:: *immigrants settle city, it suffers from decline, thus immigrants cause it*

non sequitor (it does not follow)
: claim made on linking facts with no connection
:: *he is blind, so he is unhappy*

ad hominen (to the man)
: claim made on personally attacking other disputant
:: *he cannot be a good scientist, if he is a micronationalist*

ad verecundiam (appeal to questionable or faulty authority)
: claim made on a source with arguable credibility
:: *dr. smith says that stars are small dots in the sky*

begging the question (circular argument, tautology)
: claim made on missing evidence
:: *we should cut the science budget due to useless research done*

false (or weak) **analogy**
: claim made on implying two things are similar
:: *if we can go to moon, why we cannot cure the influenza*

false dilemma (false dichotomy)
: claim made on assumption there are only two possible answers
:: *either we ban pornography or the civilisation will continue to decline*

red herring
: claim made on distractive statement
:: *why to worry about whales, if there is an unemployment here*

ad baculum, ad misericordiam (appeal to fear or pity)
: claim made on substituting emotions for reason
:: *if you do pass this letter to 10 friends, you will face bad luck*

straw man
: claim made on oversimplified evidence
:: *those who favour gun control cause criminality in the streets*

slipper slop (snowball argument, domino theory)
: claim made on suggestion that one thing leads to other negative things
:: *vivisection reduces respect for life, and if we do not respect life, we will tolerate violence and thus we cause end of civilisation. we have to ban vivisection.*

burden of proof (appeal to ignorance)
: claim made on not proving something makes it true
:: *since you cannot prove that gods do not exist, they exist*

equivocation
: claim made on homonymy
:: *giving money to charity is right thing, so they have right to it*

ad populum (bandwagon appeal)
: claim made on assumed popular support
:: *everyone likes watching TV thus it is good*

undistributed middle
: claim made on premise, which may or may not overlap
:: *all wolves have hair, all men have hair, thus all wolves are men*

Galileo had frequently leaky argumentation
: and using some data (not necessarily his) lead to **testable conclusions**
:: he refused Kepler's orbital conclusions (elliptical trajectory) because of Platonic axiom (circular t.)
:: he refused Grassi's comet description (supra-lunar) because of Aristotelian axiom (sub-lunar)

researcher vs **quasi-scientist** (or anti-scientist, sometimes layman)
: mostly confused, unaware of the power of relevant arguments

: instead of argumentation, they turn to swearing to Scientific Method (hypothesis testing)
:: performing certain rituals, the Method, is rewarded by Truth revelation
:: bear's service to the science

… and social aspects of scientific method

researchers often search, **who painted** that white swan to black rather than **why it is** black & not white
: scientists never should

: frequent application of *post hoc* hypotheses
: frequent data fishing – concealment of negative results
: frequent publishing in second rate journals, pre-elected reviewers, *etc*.

superstition (a magic belief)

: **methodic incorrect** knowledge
:: generalisation & connection of phenomena without shown causality

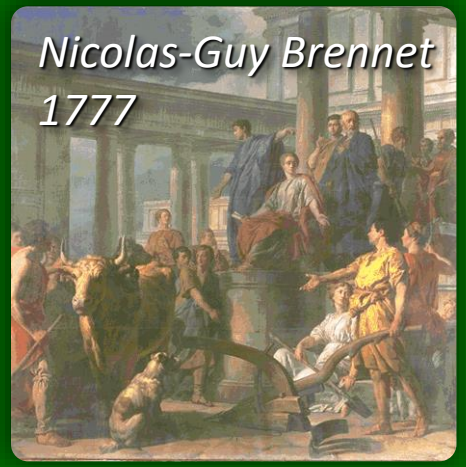
superstition is in direct **conflict** with **critical thinking**

critical thinking (scepticism) requires **literacy**

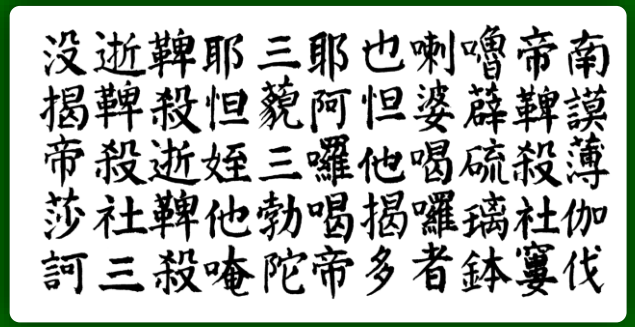
: optimally in phonetic script (alphabet) – wider literacy
: records vs oral memory (external cognition)
:: awareness of changes & their easier understanding

: increased literacy – hussites, woman suffrage

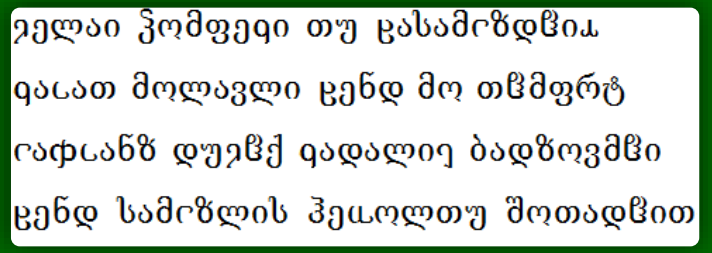
homeopathic solutions
: 1C = 1 : 10^2, 10C = 1 : 10^{20}
: analytical grade water 4C (1 : 10^8)
: 12C – not a single molecule (1 : 10^{24})
: actually used up to 50000C (1 : 10^{100000})



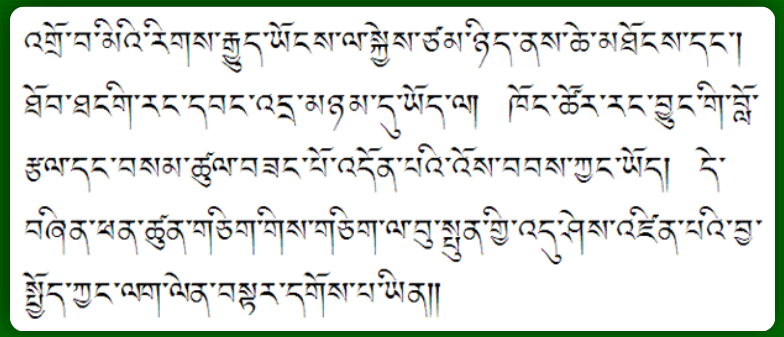
: Gaius Furius Cresinus (157 B.C.E.)
:: reality of magic



characters
: up to tens of thousands

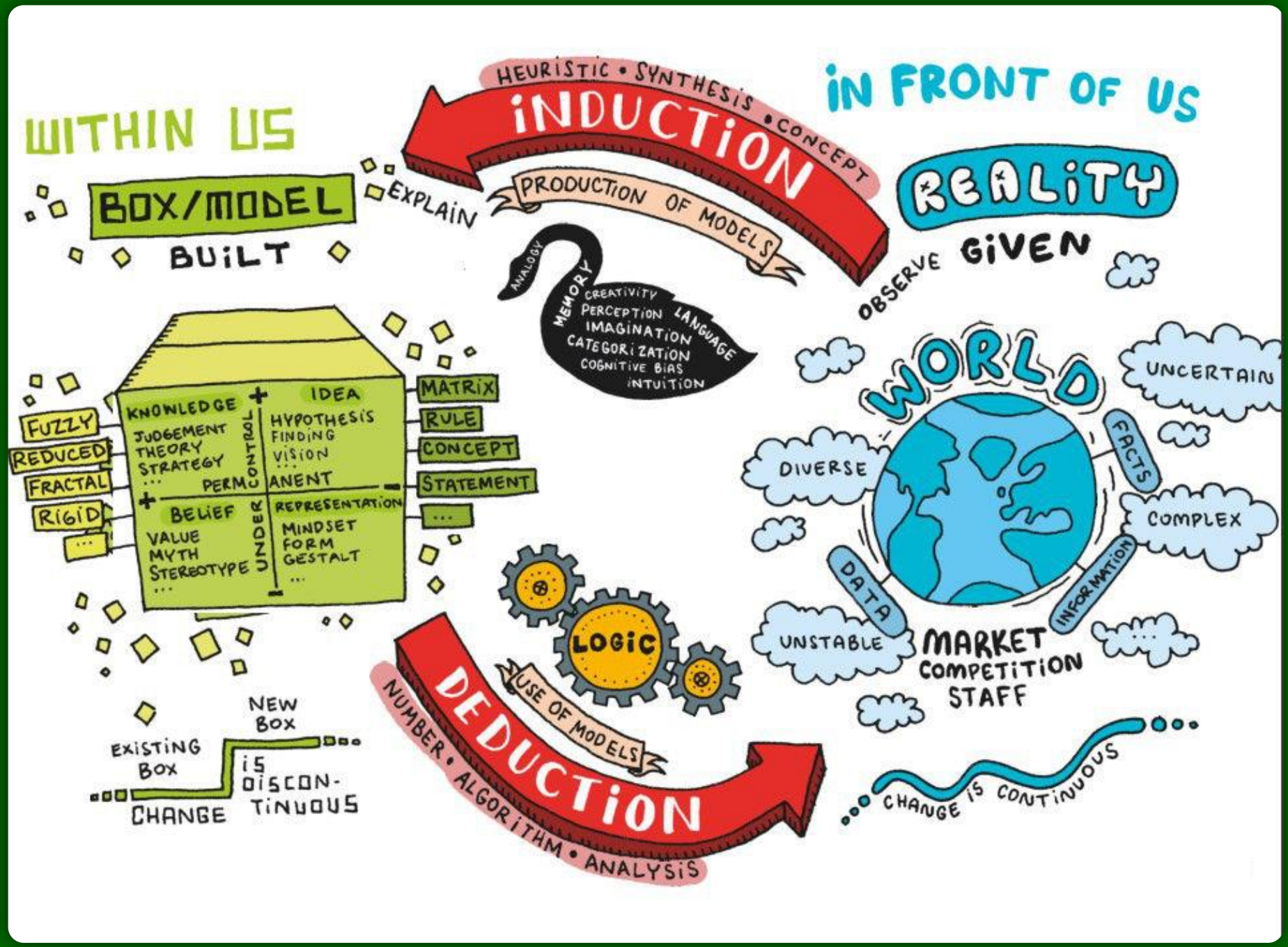


alphabet
: up 40 letters



abugida
: hundreds of syllabic letters & ligatures

what we work w/ gaining knowledge?



ethics of scientific conduct

misconduct

how may the scientific conduct go wrong?

what should not we do in science?

: questionable research
:: negligence, fraudulence
: questionable publishing
:: also reviewing
: questionable financing
:: spending, fundraising

: tolerance to questionable practices
: not putting one's interests into other's way

what to do when discovering scientific misconduct?

: are there any tolerable limits?
:: is there a harmless misconduct?
:: is it acceptable to marginalise misconduct?
: is reporting a misconduct a snitch?
: who is responsible for dealing with scientific misconduct?

: internal & third-party research integrity institutions

why do people misconduct in science?

: psychological pressure
:: internal
:: external

: human mind & society
:: evolutionary behaviour mechanisms
::: ambitions ...
::: conformity, social success ...

how to distinguish honest error from misconduct?

: formally wrong
:: inadequate evaluation and presentation process
::: picture & data manipulation (*Corel*-ation)
::: statistical manipulation (*p*-hacking, HARKing)
: contentually wrong
:: apparently wrong inputs
: methodically wrong
:: inadequate methodical approach

: critical thinking & argumentation
:: detecting, uncovering, exposing
of fraudulent scientific conduct

research process based on the scientific method

distinguishing repeatable phenomenon from random variability (noise)

: so, how to be sure that what we measured is not just „an information noise“

evidence for relation between **such phenomenon** and **circumstances**

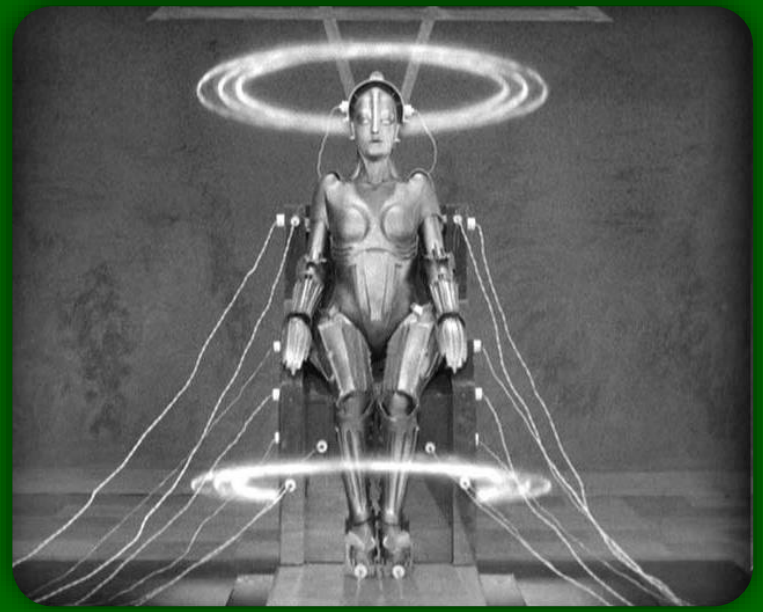
: hard decision on what is a relevant circumstance and what is not

generalise the relations and predict unobserved phenomenon

: correct chaining of circumstance-phenomenon causality

test the prediction to justify or falsify the generalisation

: empirical arrangement
:: and its evaluation
: compelling arguments in a favour of accepted hypothesis



types of empirical studies

quantitative research

: studies objectivity
:: observation
:: experiment

advantages

: independent on researcher
: results are general and universal

disadvantages

: prone to study design errors
: prone to biased approach
:: wishful thinking

qualitative research

: studies intersubjectivity and subjectivity
:: anything what's not a quantitative research

advantages

: informed insight into the situation
:: idiographic research

disadvantages

: dependent on researcher
and studied subject(s)
: prone to study design errors
:: no controls possible

mixed research

research types
by applicability

: basic research
:: scientific knowledge, which serves to acquire new knowledge
:: there is no applied research without it, only engineering

: applied research
:: scientific knowledge transformed into technology

: Mr. Faraday, what is the usefulness of your electromagnetic device?
: Someday you can tax it, Mr. Prime Minister.

an anecdote

empirical test approaches

or basic arrangement of empirical study

observation

: seems more natural
:: historically older in science
:: common in engineering

: descriptive study
: analytical study

ideal case
: researcher is not involved in the process of the observation & does not influence the observed

disadvantage
: experimental objects do have the control over process

observation types

descriptive study (exploration)
: casuistry – interesting cases (medicine)
: correlation study – appearance of A in dependence on appearance of B
: cross-sectional study – description of subjects and their properties

analytical study (confirmation)
: case-control study – retrospective search for cause
: cohort study (=incidence, prospective, longitudinal)
:: **cohort** – set of subjects for which we know actual level of exposition by studied factor
::: we observe the changes after exposition
:: better than a case-control study, but demands lot of subjects (cohorts)

arrangement
: prospective – we wait what happens
: retrospective – we search back in time

ways of observation

: **isomorphic observation** (observe as much as possible)
:: the most effective
:: recording technique

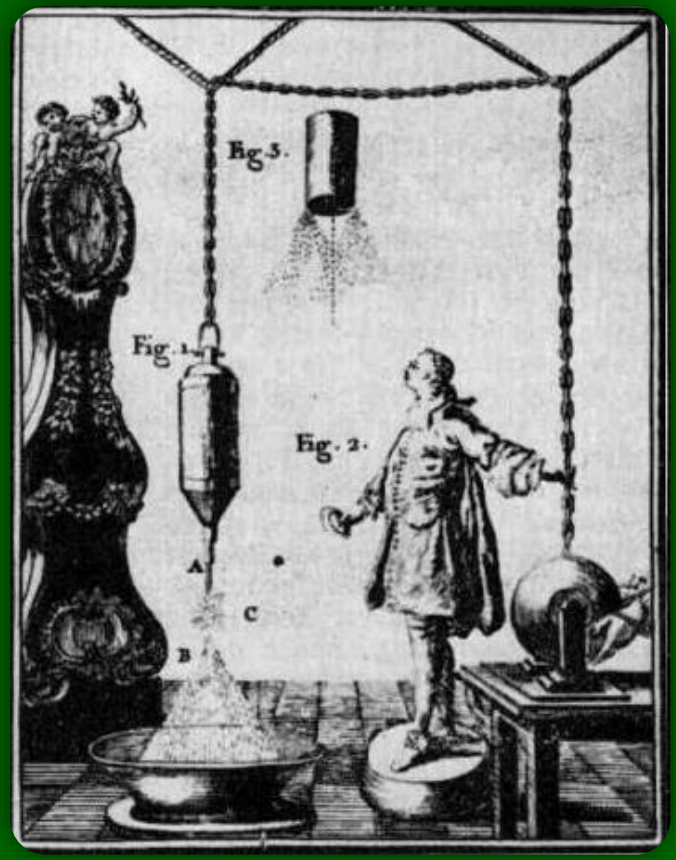
objectivity, reliability, validity

: **reductive description** (we observe only what we want to)
:: record sheets, programmes

experiment

: easier than observation
:: less demanding on preparation

: intervention study

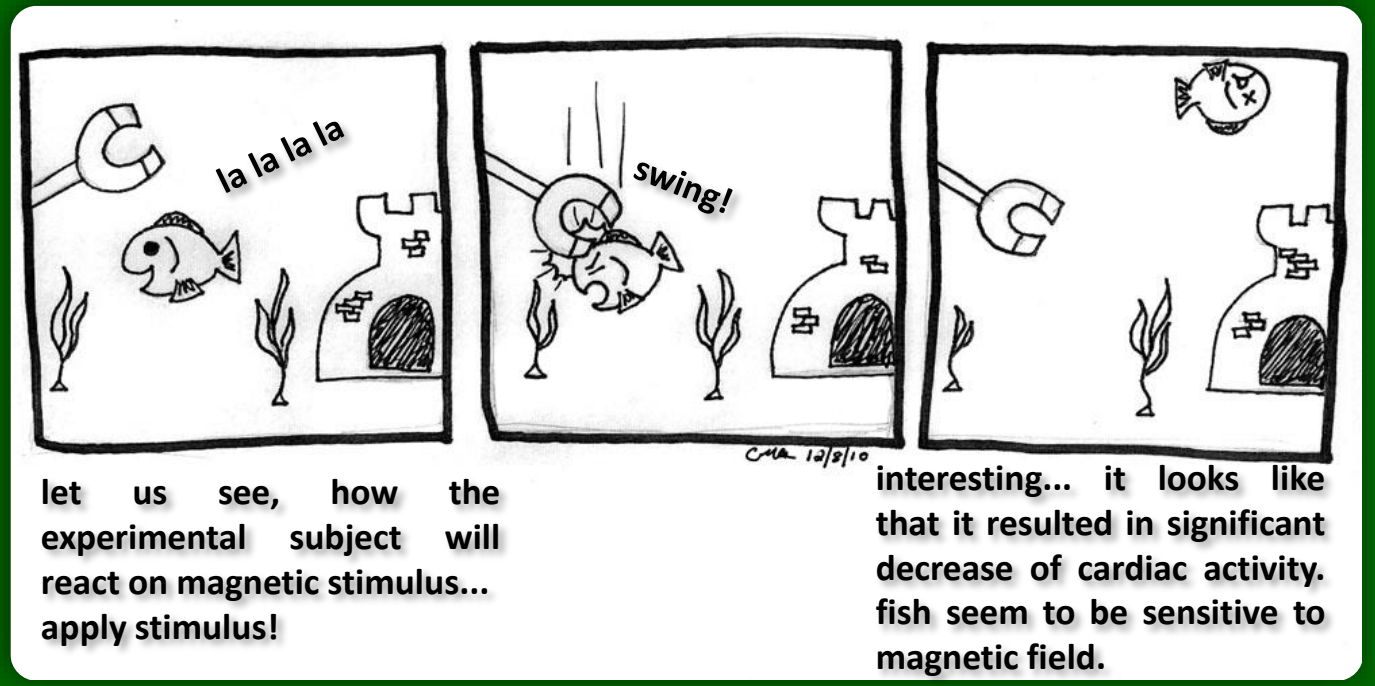


ideal case
: researcher has control over entire process of the experiment, mostly choice of experimental objects

disadvantage
: risk of experimental artefacts

simple and complex arrangement
: one study – one factor?
:: single variable vs multiple variables
::: interactions!

basic and experimental set
: representativeness
:: sorted set, generalisation of results
: set homogeneity
:: increases the power of the test



controls
: role of negative and positive (method works) controls
:: controls serve to demonstrate relevance of methods
:: placebo, blind trial, double blind trial, open-label trial
: randomisation
:: unloaded object distribution into groups

data independence

: pseudo-replicates

:: leaves of one plant

::: 100 trees & one leave, not 2 trees & 100 leaves

:: eggs in nest

::: one egg, more nests

: limit the number of observers, who evaluate only part of subjects

data arrangement

: representativeness, measurement accuracy

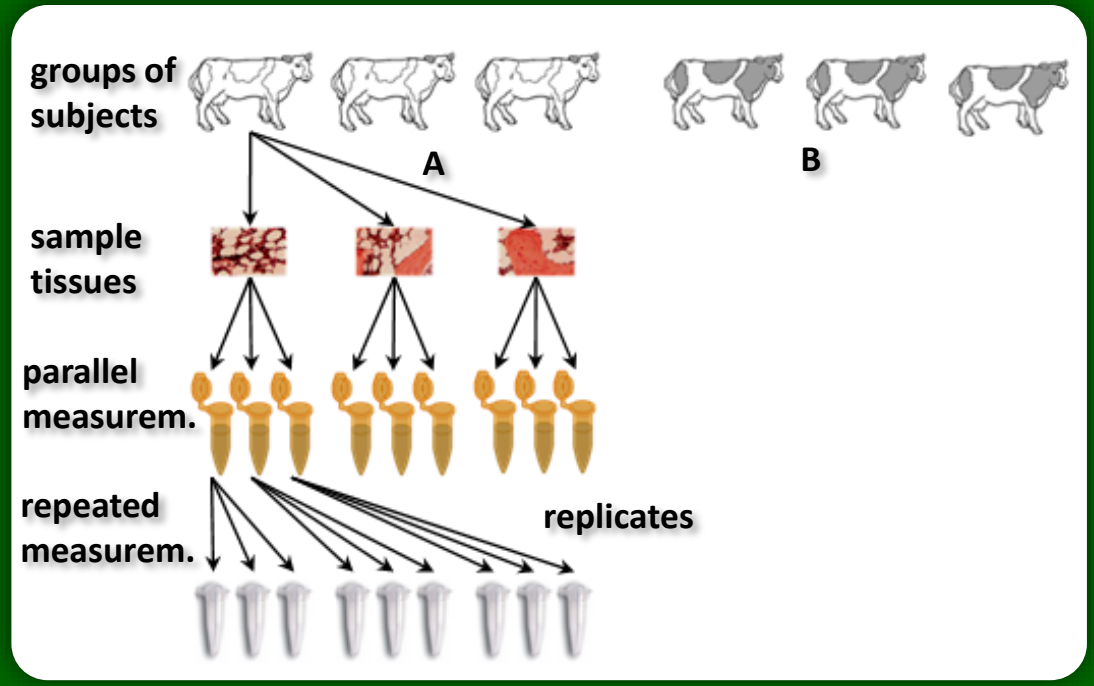
:: sampling

:: experimental replicates

: measurement precision

:: technical replicates

analysis of protein content in tissue



balanced data in individual groups

: in all groups & subgroups is same/similar number and type of objects

basic stages in empirical study

defining the goal

exploration vs **confirmation** vs **intervention study**

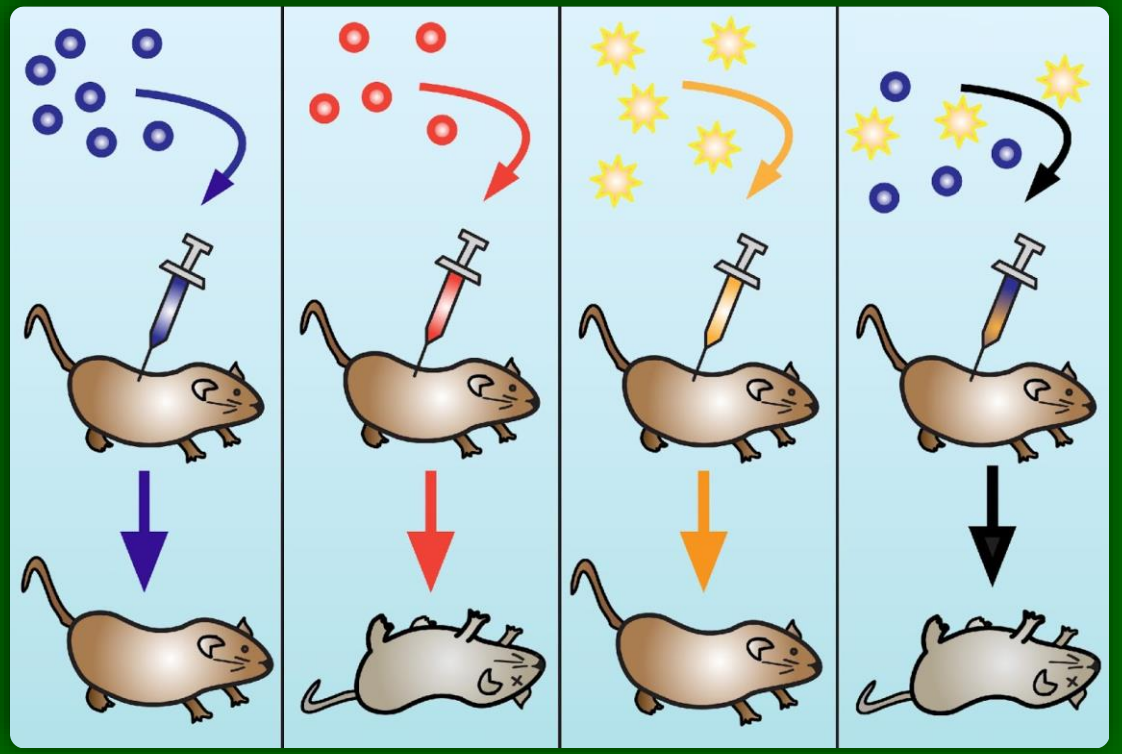
: within confirmation & intervention study the hypothesis must be casted before data acquisition
: within exploration study must be clear what will be minimally observed

as most precise hypothesis formulation as possible

: does have the hypothesis sense?
: is it worth the effort and how much effort?
: is not the answer already known?

find the way to answer the hypothesis

: is there a way to answer it?
: is it reasonable that I try to answer it?

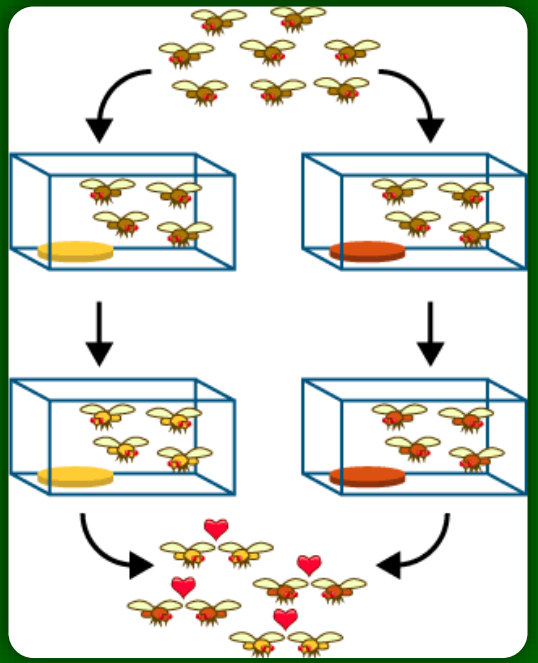


types of answers to casted hypotheses

: **cross trial** yes / no

: **asymmetric trials** yes / do not know

: **heuristics** do not know / do not know



: **positive** // **negative** results
:: existence // absence of a certain phenomenon
::: controls, power analysis
:: yes // do not know
::: incorrect approach, subjective

: **repeating** experiments
:: assure your-self vs convince opponents

choice of proper method

: **what shall we observe**
:: direct and indirect methods, data validity

: **how shall we observe it**
:: technical performance

: **with what certainty**
:: reproducibility

: **with what precision**

studies of special interest

: **animal testing**
:: ethics committee
:: permission to work with animals

: **human testing**
:: ethics committee – IRB (IEC, ERB)
:: personal data management
:: informed consent

confusing variables

we are not interested in them, they „spoil“ result

: elimination (may decrease representativeness)

: randomisation (representativeness)

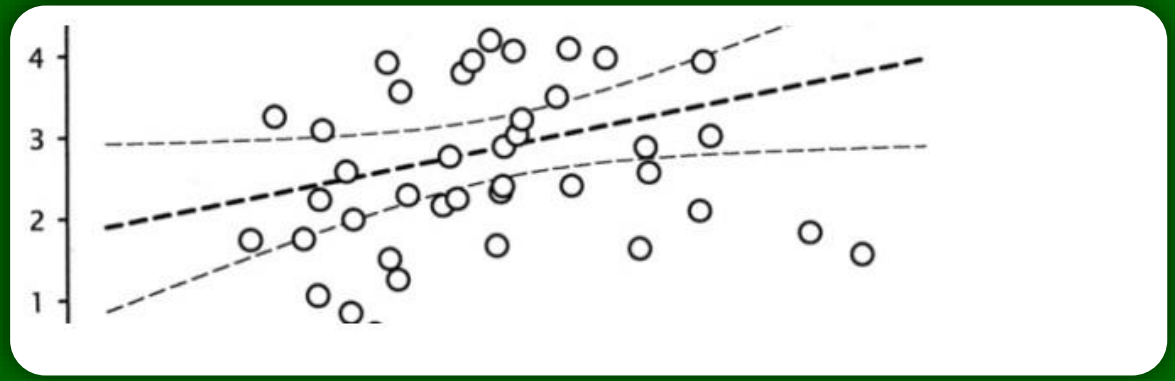
: blocking (only within experiments)
: pairing control + object, Latin squares, balanced arrangement

errors in acquired data

: **stochastic** vs **systematic error** (bias)
:: only by means of systematic error we could explain a false positive result (error type I)
:: source of systematic error – correctable (but also wrongly) by means of randomisation

: **low method specificity** vs **low method sensitivity**
:: false positive vs false negative
:: use of independent method for data acquisition

result evaluation
: **statistics**, „side“ results, **result interpretation**



size of a sample set

risks of small sets

: risk of an error of type II

:: false negative results

::: probability of unjustified acceptance of null hypothesis when alternative is valid

: impossibility to block confusing variables

risks of large sets

: risk of an error of type I

:: false positive results

::: probability of unjustified rejecting null hypothesis

sufficient size of the sample set depends on

: variability of observed quality

:: low variability allows small sample set size

: number of observed independent factors

:: more factors demand larger size

: technical possibilities and required level of certainty (precision)

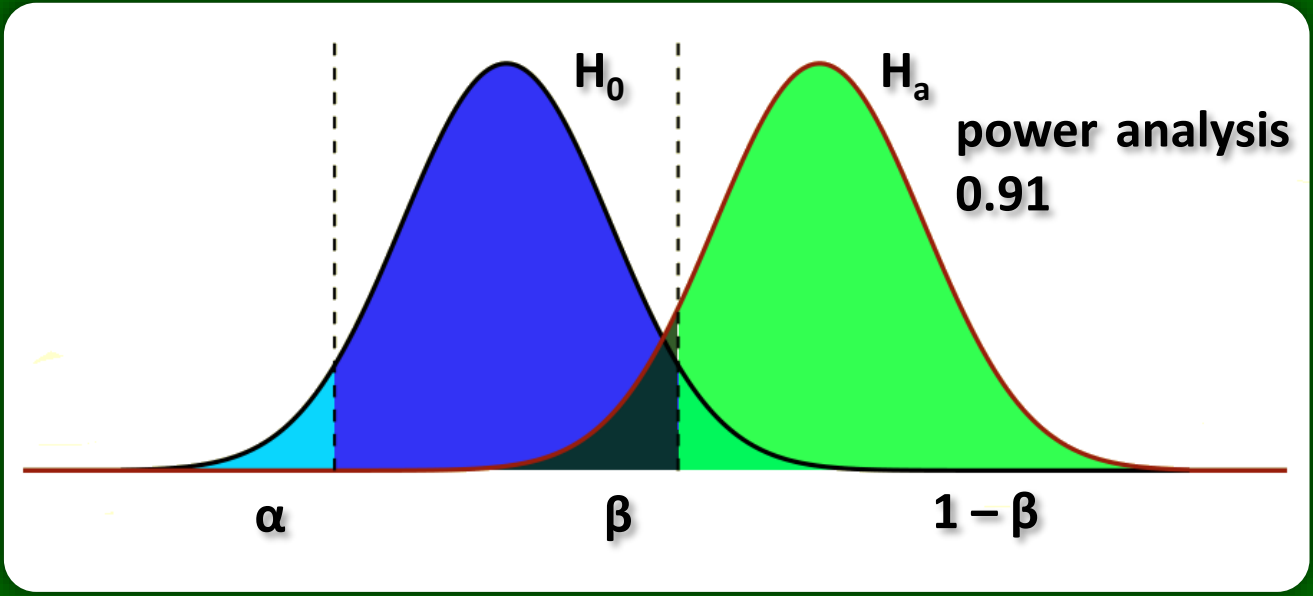
statistical power analysis

: probability of correct rejecting of null hypothesis, if it is invalid

: power analysis equals **1–β**, where **β** is a measure of false negativity
:: as the power analysis increases, probability of error type II decreases
::: probability that we do not discover the dependence even it exists

: determining suitable sample size

: usually taken as reasonable > 0.8 (never < 0.7)



error probability
α – type I
β – type II

correct data handling

: **reading precision** (1 °C; half of the smallest mark, analogue)

: **average**

: **standard deviation** ($\sigma = 1._6$)

: **outlying values** (no outlying one; T-test)

: **limit of confidence** (precision; $11._9 \pm 1._4$ °C) $\mathbf{T = \overline{T} \pm t_\alpha \cdot \sigma_{\overline{x}}}$

: **accuracy** (if we have standard; t-test)

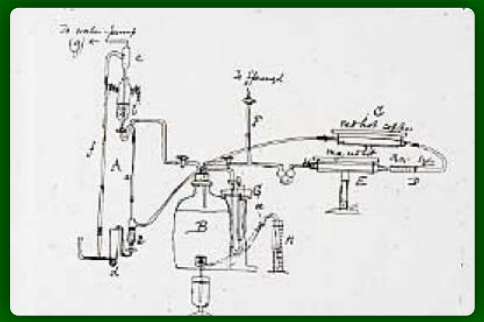
:: (arbitrary) real temperature = 11.78542 °C

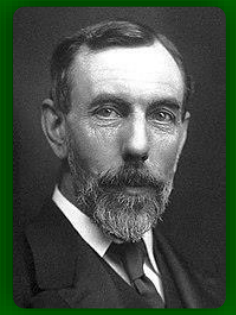
even with an imprecise measure we may get „precise“ data

observation	value
1	11
2	12
3	11
4	11
5	15
6	10
7	13
average	**11.85714...**

12 ± 1 °C

: how Ramsay & Rayleigh discovered argon
:: if the measurement error is 0.03%, difference of 0.48% must be significant
::: difference between unit mass of different nitrogen preparations





: Faraday studied the effect of magnetic fields on emission spectra
:: he saw no effect (1862); Maxwell confirmed it
:: Zeeman (1896) repeated the experiment & found spectral line splitting
::: more accurate spectrometer, but explanation only by quantum physics
::: Faraday had good scientific instincts but inaccurate instruments

important remarks to the research process

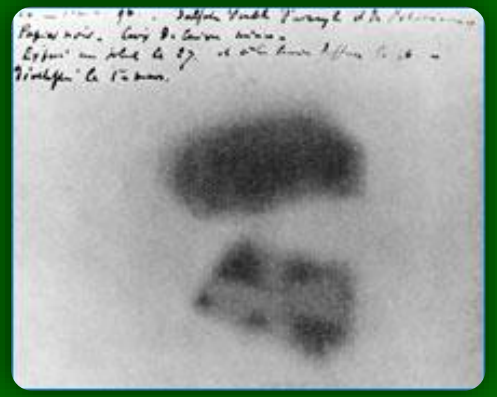
: never to forget, which quantities we **would like** to study and which we **in fact** did measure

: never to forget to **doubt**

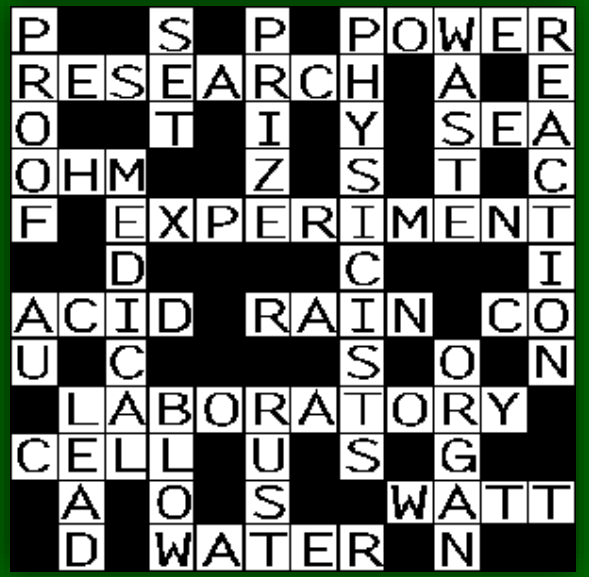
: take care about everything **suspicious** (thus potentially **interesting**)

: never to forget to **think**

: **finish the work**!



: *Henri Becquerel*
& exposed photographic plates



research is like cross-word puzzle
: we start with what we think is the easiest
: we cross check
:: we erase and re-write
:: we make mistakes or the task is ambiguous

scientific method in research praxis
: general approach leading to logical conclusions, not a particular procedure

scientific conduct

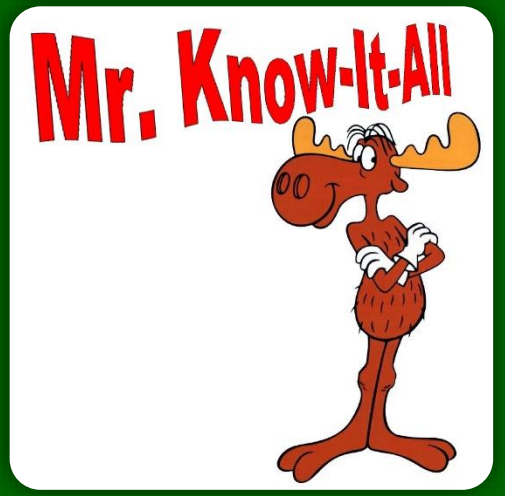
: collecting unbiased data
: methodically correct evaluation
: formulation of valid conclusions
: results presentation

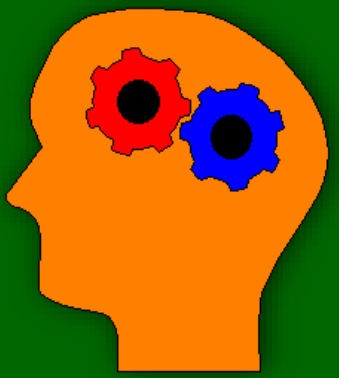
: working (mostly) within a collective
: community depends of work of others

: positive results are expected from science/scientists

nature of scientific conduct

scientist is
: lab technician
: engineer
: teacher
: student
: publicist
: manager
: politician





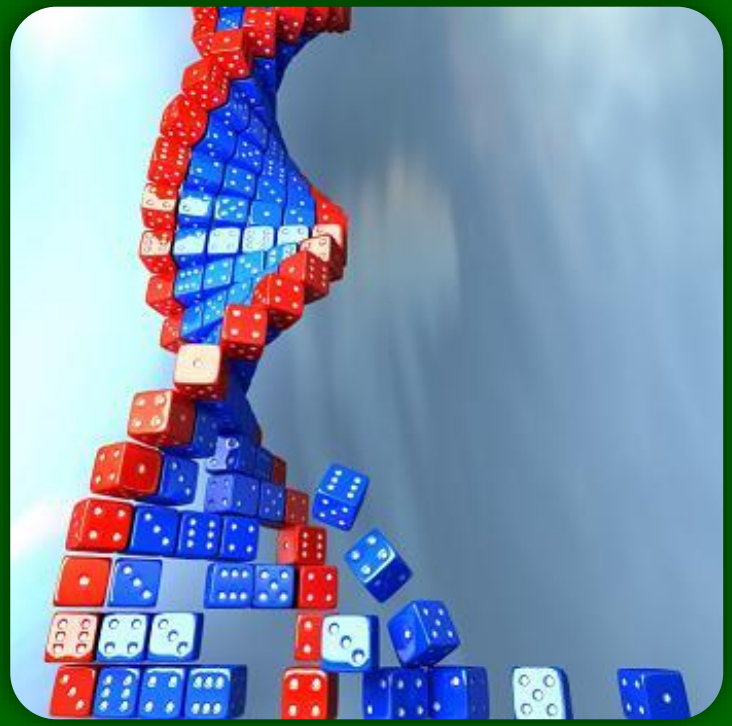
to cut a long story short
: labourer of knowledge
:: often over-specialised, with a limited perspective
: majority of activity are learned on the job
:: soft skills education is more common today

science is first of all a human activity

scientific knowledge

: uses often intuition and guesses instead of cold reasoning
:: **serendipity** – role of lucky co-incidence (*fortune favours the prepared*)
:: **heuristics** – pure empiricism

: hypotheses are not always tested in a correct manner
:: incorrect test interpretation or conduction



... without anger and zealotry ...
Tacitus
(*sine ira et studio*)

... scientist has a healthy scepticism,
suspended judgement,
and disciplined imagination ...
Edwin Hubble

basic dangers to scientific conduct
: wishful thinking, egocentrism and intellectual inertia

during acquisition of **scientific** knowledge, the correction appears
: directly by original authors
: or in wider scientific community

! : abduction
: *ad* & *post hoc* hypotheses

sources of unethical behaviour in science

: career pressure
:: desire to reach the top positions in community hierarchy
::: semi-isolated (scientific) society
:: high level of inner & outer competition

: social pressure
:: desire to excel & to be useful

: circumstance pressure
:: tendency to ignore unexpected results
:: negligence, haste,
lack of consideration of the circumstances

: personality pressure
:: lowered self-reflection of one's own abilities
:: absence of critical approach to one's own work
:: hypercriticism to the work of others
:: difficult control over conflicting personal traits

disappointment and fear of failure →
→ sense of threat →
→ unethical behaviour

cognitive dissonance

... to recognise failure is an important part of scientific strategy, part of scientific ethics ...
Daniel Friedan

misconduct vs honest error
disinformation vs misinformation

intentional misconduct (*fraud*)
: discrepancy between reality and statement caused by manipulation

unintentional misconduct (*slip*)
: discrepancy between reality and statement caused by negligence

honest error
: discrepancy between reality and statement caused by fallibility

honest errors in science are **common**, *de facto* science runs on them

do not be afraid of **honest errors in methodic approaches** in research

: Columbus & America

: Daniel E. Koshland

pragmatic point of view (why frauds happen not so often, even if you are not overseen)
: uninteresting data are not worth forgery
: interesting data will be reproduced one day

: Woo-Suk Hwang & stem cells

scientific misconduct – system characteristics of research community
: N. Lacetera, L. Zirulia, *J Law, Economics & Organization* **27**, 568-603, 2008
: B. C. Martinson, M. S. Anderson, R. de Vries, *Nature* **435**, 737-738, 2005
:: 10 – 15 % of scientists manipulate measured data in their own image

unethical conduct in science
(execution, abet and cover)

: forging data & results
:: starting with complete fabulation up to overlooking critical data (*forging*)
::: mostly manipulating data & their presentation (*doctoring*)

p-hacking manual
http://shinyapps.org/apps/p-hacker/

: stealing someone else's data & results
:: to strut in borrowed plumes – reviewers, supervisors... (*plagiarism*, *rogeting*)
:: real author is not mentioned as author (*ghost-writing*)
::: who is and who is not a co-author?

: Chris Sadler; *Roget's Thesaurus*
:: left behind → sinister buttocks

: Schweik's effect (of trade with dogs)
:: publish one paper many times (*self-plagiarism*)
::: under certain limited circumstances may by ethical

including anything,
what may happen
on any workplace

: wrong, dangerous or socially unacceptable research
:: unauthorised experiments on humans and animals
::: including manipulation with DNA or cyborgisation
:: uncontrolled weapon development

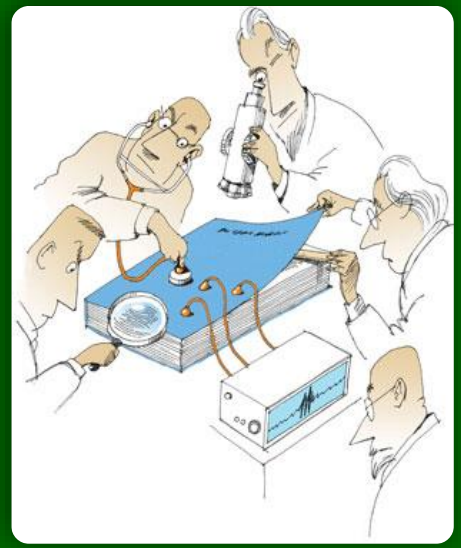
conflict of interests
harassment
nepotism
harming the others' interests...

: manipulation, misuse or ignoring of ideas
:: citation amnesia – intentional unquoting of other's work
:: citation fabulation – quoting non-existent or irrelevant papers

if you ask scientists directly
: 2 % forged results
: 34 % did not work rigorously

if you ask about scientists (indirectly)
: 14 % forged results
: 72 % did not work rigorously

project review
: 20 % of project proposals through-put in connection to committee members
:: in less developed countries it is 40 – 60 %



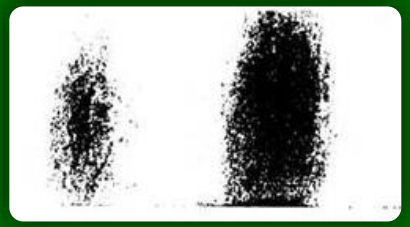
peer-to-peer review
: includes version of so-called altruistic punishment
:: keeps co-operating group functional

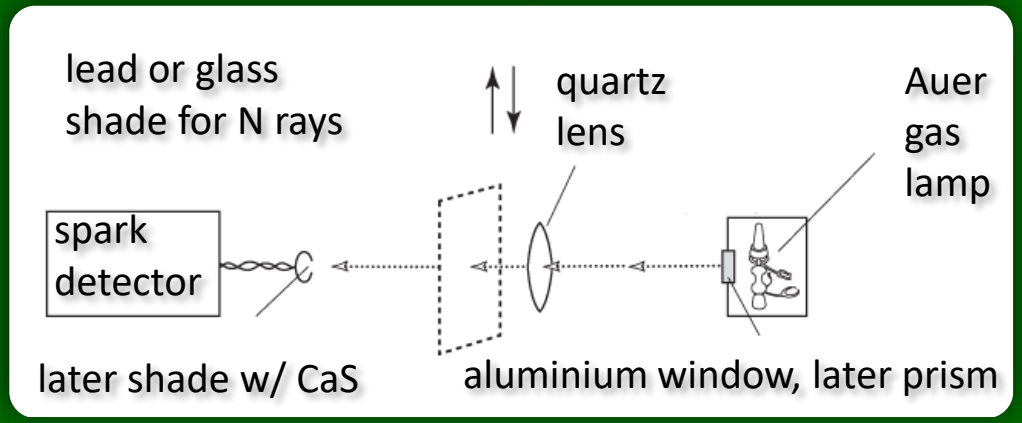
influence of political and economic power on scientific work
: 96 % of pharmacologic paper authors with positive results are connected to manufactures
: 60 % of authors with neutral results
: 37 % with negative results

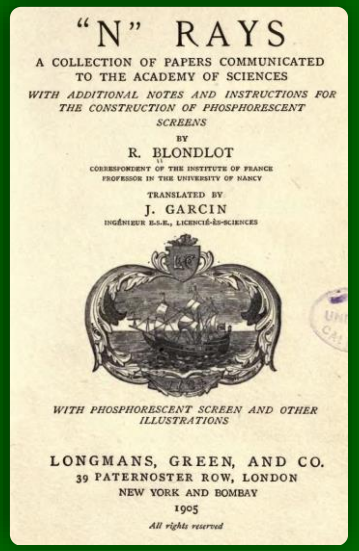
it would like to be a science, but it does not follow rules

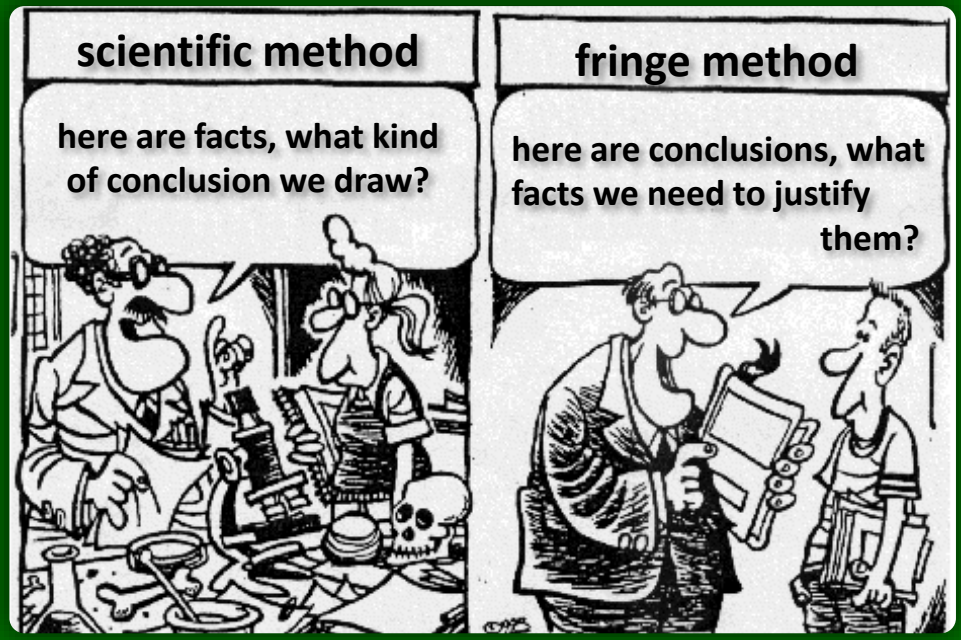
pseudo-science
fringe science

N rays (1903)
: Prosper-René Blondlot announced them
: 30 papers in one year
: no-one was able to reproduce the results






"N" RAYS
A COLLECTION OF PAPERS COMMUNICATED TO THE ACADEMY OF SCIENCES
WITH ADDITIONAL NOTES AND INSTRUCTIONS FOR THE CONSTRUCTION OF PHOSPHORESCENT SCREENS
BY
R. BLONDLOT
TRANSLATED BY
J. GARCIN
WITH PHOSPHORESCENT SCREEN AND OTHER ILLUSTRATIONS
LONGMANS, GREEN, AND CO.
39 PATERNOSTER ROW, LONDON
NEW YORK AND BOMBAY
1905



Robert W. Wood – *Nature* test, 1904
: unseen removed component (aluminium prism)
or put hand in a ray trajectory
:: rays were observed
: assigned observation to cognitive errors

no prestigious journal **will publish** any important discovery **pre-published without review**

rules to distinguish fringe from **science?** it *could not* be done **positively**

science: **primary goal knowledge** **fringe:** often side effects: ideology, culture, business

ID : bible, UFO : anti-establish

knowledge evolves it is not evolving experiments justify only

iconoclast in science is hero, not heretic

pseudo-science has an agenda

cui bono?

knowledge is tested testing knowledge is taken as heresy

science like more new questions than answers

conflicting data are interesting conflicting data are ignored & suppressed

everyone likes soothsay no one really tests it

no knowledge stays once for ever knowledge is often dogmatised

logical impossibility to disprove is not a proof

knowledge must stand alone knowledge must be supported by authority

supporting facts by scientific degrees

unambiguous language vague & ambiguous language

energy, vibration, field

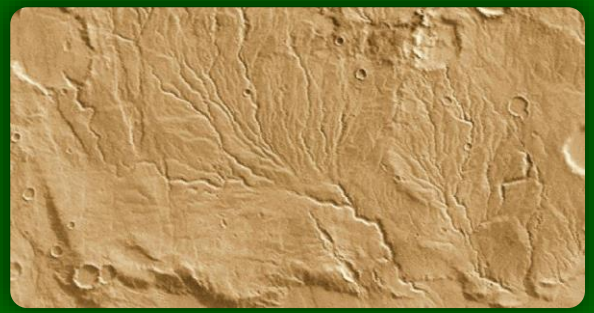
„**pirate code** is more what you'd call *guidelines* than **actual rules**“ **captain Barbossa**

why do we deal with pseudo-science?

when we could over-skip it with a smile...

live and let die

: Martian channels, Schiaparelli (1877), Antoniadi (1909)



: Freud and a case of childless woman

origin of pseudo-science? cognitive biases

desire to see something causes we see it

desire for pure force affecting our lives

dangerous aspects of pseudo-science

: charlatanry, commercial frauds, cults, politics

: distrust to unknown & over-confidence in simple solutions

and wasn't science once called pseudo-science?

on the break of new paradigm

: A. Michelson, J. J. Thomson, A. Wegener

in science, we don't use the common sense, but critical thinking and doubts

and could not science become sometimes pseudo-science?

when unable to test new hypothesis

: string theory; an attempt on changing rules of „game“ only to „win“

: **data manipulations**
:: fraudulent, but not always conscious behaviour (anti-threat defensive reaction)
::: data forging, stealing, copying, ...

: **manipulating research authorship**
:: co-author has to be able to defend all conclusions
:: honorary co-authorship (no) vs boss inclusion (yes)
::: for less important collaboration use *acknowledgement*

there is no cost to getting things wrong.
the cost is not getting them published.
Brian Nosek

: **manipulating citations**
:: purposive behaviour
::: citation gangs, effect of St. Matthew, effect of the Omniscient, citation deflection, ...

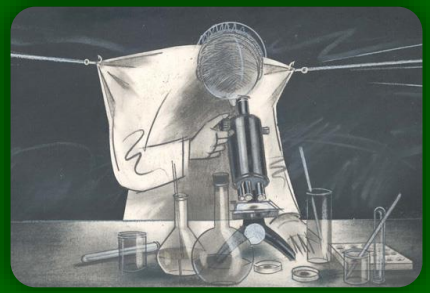
: **manipulations in peer-reviewed journals**
:: „forthcoming“ editors
::: choice of reviewers, ignoring legitimate objections from scientific community
:: private companies co-ordinating fraudulent processes
::: starting with innocent offer to help authors (proof-reading)
::: up to ghost writing of *ms* from preforms & manipulated contact lists of reviewers
:: corrupting journal editors under false pretend of helping the new authors
:: direct attempts to buy the publishing (sometimes with threats)

influence of system

: grants, grant committees
:: malversation and clientelism
: peer-to-peer reviews
:: laziness, shallowness
::: probably result of low or null sanctions
: competitiveness
:: may limit the research
::: supresses negative results, requires only those positive
: collaboration
:: should be normal
::: competitiveness and legal norms (companies) may impede
::: anything could be achieved,
if not presented under particular name

influence of society

: political & social choice of research topics
:: limiting the research and its financing
: pop-science
:: science and research commercialization



abuse of scientists

: expertise
:: falsifying expert opinion

: un-ethic research
:: under pressure

abuse of knowledge

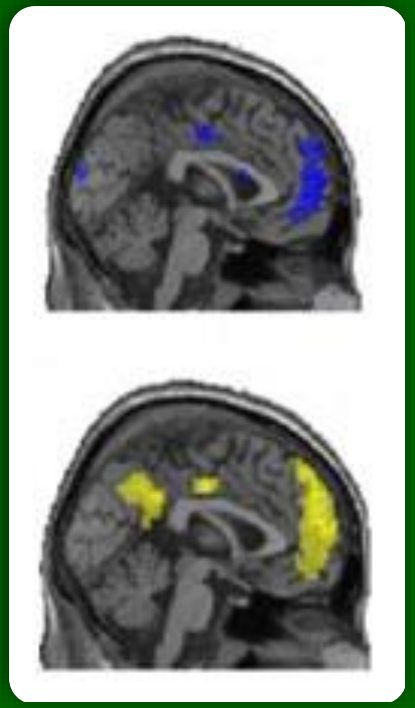
: knowledge is not good *per se*
:: but neither evil
:: it is not an excuse anyway
::: power → responsibility

with great power
there must also come great responsibility;-)

: employees respect the law
:: scientist moves on its edge
::: scientific auto-censorship

vivisection

: strong rules
:: they alone are not the solution – guilt from suffering
: without vivisection it is not always possible
:: far to complex systems to study
::: HIV monoclonal antibodies, active substances
: consider the responsibility
:: benefit does not ease off responsibility



anonymity
: randomised identifiers of samples and experimental subjects
: never publish non-anonymous data

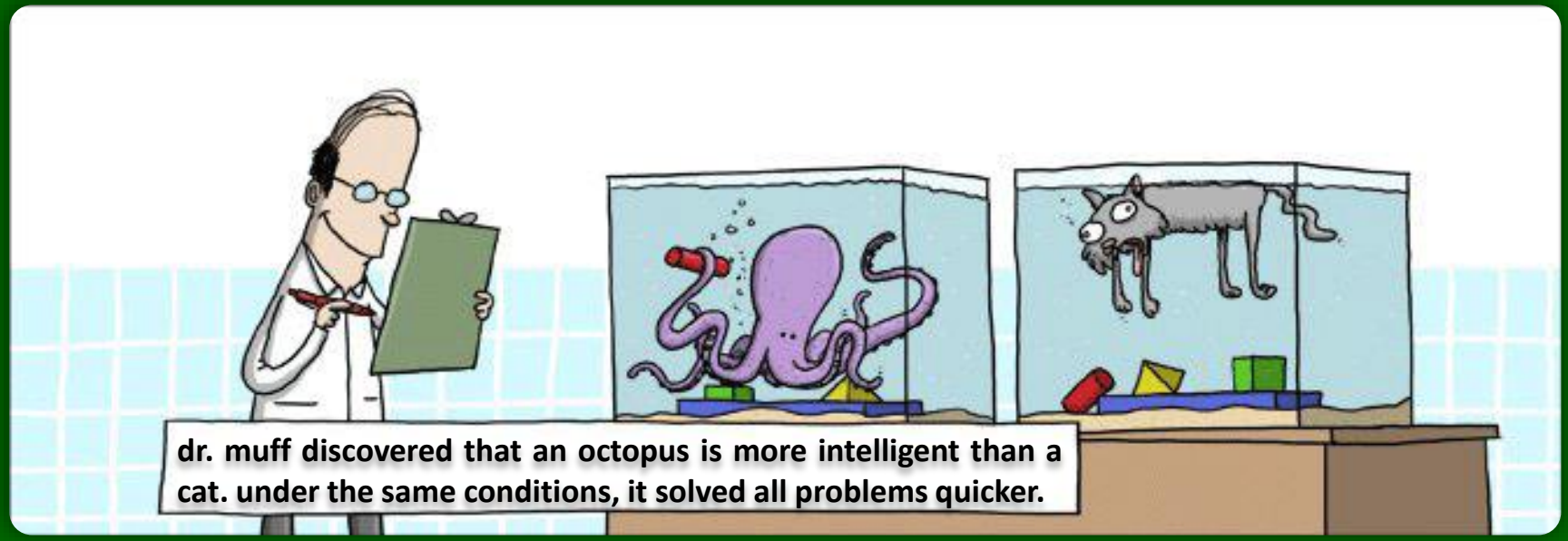
confidentiality
: if not possible to keep anonymity, than at least confidentiality

consensuality
: honest approach to all eventual experimental subjects

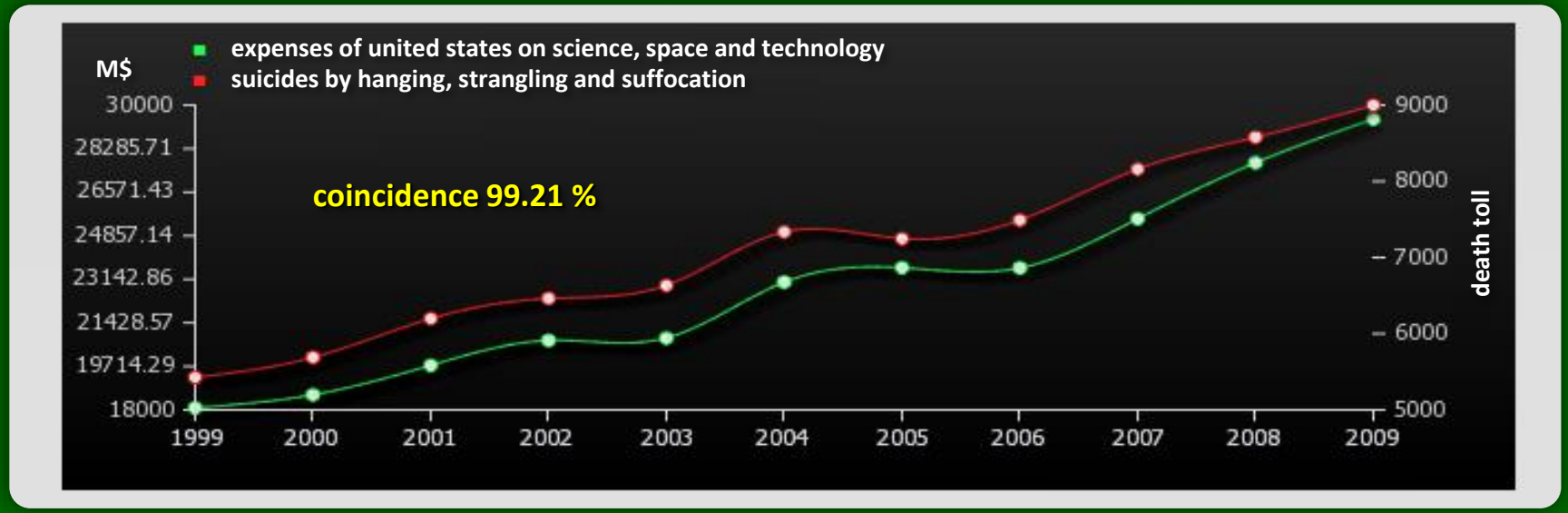
: what kind of decisions are in science?
:: how to approach research and its results
::: how to correctly acquire and evaluate data
:::: what to do with unexpected results
::: how to correctly present results
:: how to approach colleagues
:: how the colleagues are supposed to approach you

: how to avoid misconduct (ethical dilemmas)
:: knowing the rules
::: their content and also the reason for them
:: knowing the rights and responsibilities
::: co-authorship, conflict of interests, intellectual property, vivisection
:: ability to recognise the most common ethical misconduct examples
::: from other or your own sources 😉

garbage in, **garbage** out (G.I.G.O.)



correlation does not imply **causation** (often only **coincidence**)



voodoo correlation – highly sophisticated, but all wrong statistical evaluation

research

: do not do questionable research
  :: it may be questionable due to negligence or fraudulence
: do not tolerate such research in your vicinity
  :: e.g. interest groups, which may benefit form it
: do not hinder other's research because of your interests

publishing

: do not publish results of questionable research
: do not allow publication of such results while reviewing
  :: negligent or intentionally uncritical reviews
: do not hinder publishing of other's results because of your interests
  :: i.e. intentionally and unjustifiably critical reviews

financing

: do not spend grant money on questionable research
: do not allow fundraising for questionable research
: do not hinder fundraising for other's because of your interests
  :: fraudulent activities in grant agency's panels

integrity in ethics
: commitment, loyalty to certain rules and principles
: strength of character, honourability, honesty, impeccability

official frame for research integrity in Europe & Czechia
: **European Charter for Researchers 2005/251/ES**
:: EU Official Journal, march 3, 2005
: **Ethical research frame**
:: resolution of Czech government, august 17, 2005 No. 1005

research integrity in institutions and scientific community
: *Rules of Good Scientific Practice*, Max Planck Society, 2000
: *Good Manners in Science; A Set of Principles and Guidelines*, Polish Academy of Science, 2001
: *All European Memorandum on Scientific Integrity*, Amsterdam 2003
: *Ethical code of researchers in AS CR*, 2006
: *Singapore Statement on Research Integrity*, 2010
: *Montreal Statement on Research Integrity in Cross-Boundary Research Collaborations*, 2013

institutions guaranteeing the research integrity

internal

: **ethical committees (& ethical codes)**
:: ethical committee of MU (art. 14 ethical code of MU, 2008)
:: ethical committee of BUT (art. VII ethical code of BUT, 2016)

external (third-party)

: **ethic offices**
:: **Office of Research Integrity** (ORI)
::: created merging several governmental and institutional offices
:: **Nævn for Videnskabelig Uredelighed** (Denmark)

: **independent non-profit organization**
:: **UK Research Integrity Office** (UKRIO)

: **scientific journals**
:: ethical statements, plagiarism check, sharing information on frauds

The Committee on Publication Ethics (COPE)
: since 1997, advices to editors & publishers on publication ethics

difficulties of implementing ethical conduct
ideal norms vs psychological & social reality

: **struggle for survival** (and resources) – whatever fictive they may seem
:: biological adaptation devised with many survival tools
::: subjective necessity to preserve (or elevate) one's own status
::: existence of interest & support groups (e.g. citation gangs, management of scientific institutions)
::: practice of deception, selective blindness, doublethink & groupthink

: **it's very difficult to point out unethical behaviour** (not only in science)
:: often uneasy to evidence when analysing questionable results
::: only reasonable doubt, without empirical verification
:::: sometimes without mere possibility to empirically verify
::: anonymity may help detect, but also cover unethical behaviour
:::: PubPeer vs peer-to-peer review
:: covering unethical behaviour in a name of apparent stability of society by powers that are
::: false loyalty
:: easy misuse of unethical behaviour detection in a struggle of powers
:: intuitive aversion to publish doubts on ethicality of behaviour
::: denunciation, slander vs discontent, information on suspicion

: *you have to be either very brazen or very stupid to get caught at cheating in science*

Peter Gray

PUBPEER
The online Journal club

Internet Explorer syndrom : *ethical problems are not solved when they appear, but when they come out*

bioethics

where is the boundary between ethics and politics?

: bioethics is based on medicine and biology
: origin in the **Hippocratic oath**
  :: original text is out of date, changes in the reference to the gods, men only teaching, abortions, etc.
  :: a follow-on adversarial story about H. refusing a gift from Artaxerxes, an enemy of the Greeks
: today it addresses ethical issues related to the relationship between man and modern medicine
  :: euthanasia, abortions, artificial organs, gene therapy, genetic engineering, ...
  :: beneficience, autonomy, non-maleficience, human dignity, sanctity of life, ...
: significant influence of politics
  :: right to the best treatment – health insurance, price of treatment, availability of treatment, ...

contemporary critique of bioethics
: quandary ethics – rich vs poor (Paul Farmer)
  :: too much care vs no care
: bioethics lacks diversity, it is too occident – racism and xenophobia (John Hoberman)
: two necessary cornerstones of bioethics – diversity of ideas and social inclusion (Heikki Saxén)
  :: often not fulfilled

David Baltimore (1938)
: biologist, Caltech

was it a fraud?
case of David Baltimore, 1986 – 1996

Weaver D., Reis M. H., Albanese C., Costantini F., Baltimore D., Imanishi-Kari T., *Cell* 45 (1986) 247

1991 – results of fraud investigation are published
: M. O'Toole, subordinate of T. Imanishi-Kari – data were supposedly fully forged

: D. Baltimore defended Imanishi-Kari
: entrance of senator John Dingell, „hunter“ of scientific frauds
:: politicisation & media-promotion
::: Baltimore resigned from all functions
:: civil court denied the cause
::: returned to the *Office of Research Integrity*
:: animosities between former colleagues
::: T. N. Wiesel has taken over Baltimore's positions & lobbied to expel of Baltimore from scientific organisations, even to retract his Nobel prize

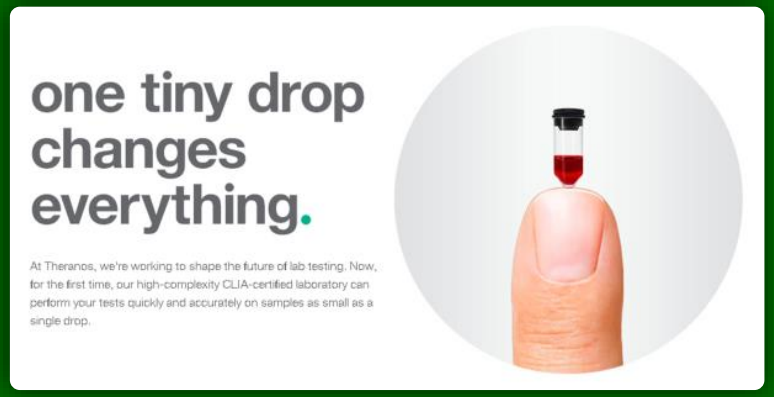
probable reasons?

: inexperience and zeal
: professional rivalry (success pressure)
: science witch-hunt by media

1996 – *Health & Human Services* decided, that **no fraud happened**
: results successfully reproduced by independent laboratory in 1993
: 6500 pages of documents and 6 weeks of closing session

case of Elisabeth Holmes and Theranos, 2003 – 2021

clinical bioanalytics start-up with massive support from celebrities (Kissinger, Clinton, Shulz)
: 19 years old E. Holmes, drop-out from *Stanford's School of Engineering* (after a year)
:: 2003 – patent for new type of microanalyser of capillary blood (fear of needles)
: start-up *Theranos* with *Edison* analyser, > 200 analytes from 5 µl of blood
:: never peer-reviewed technology, no proper technical documentation
:: internal doubts since the start (Tyler Shulz – employee and grandson of director)
:: revealed by John Carreyrou of *The Wall Street Journal* in 2015
:: analyser never worked, results were taken from classical, „checkout“, measurements
: rocket founding raising, in 2014 value of 9 G$, in 2018 it was 0 $
:: stealth-mode running – no official info going outside
:: EH is facing 11 years sentence for being found guilty of fraud and conspiracy
: 2019 HBO documentary *The Inventor: Out for Blood in Silicon Valley*



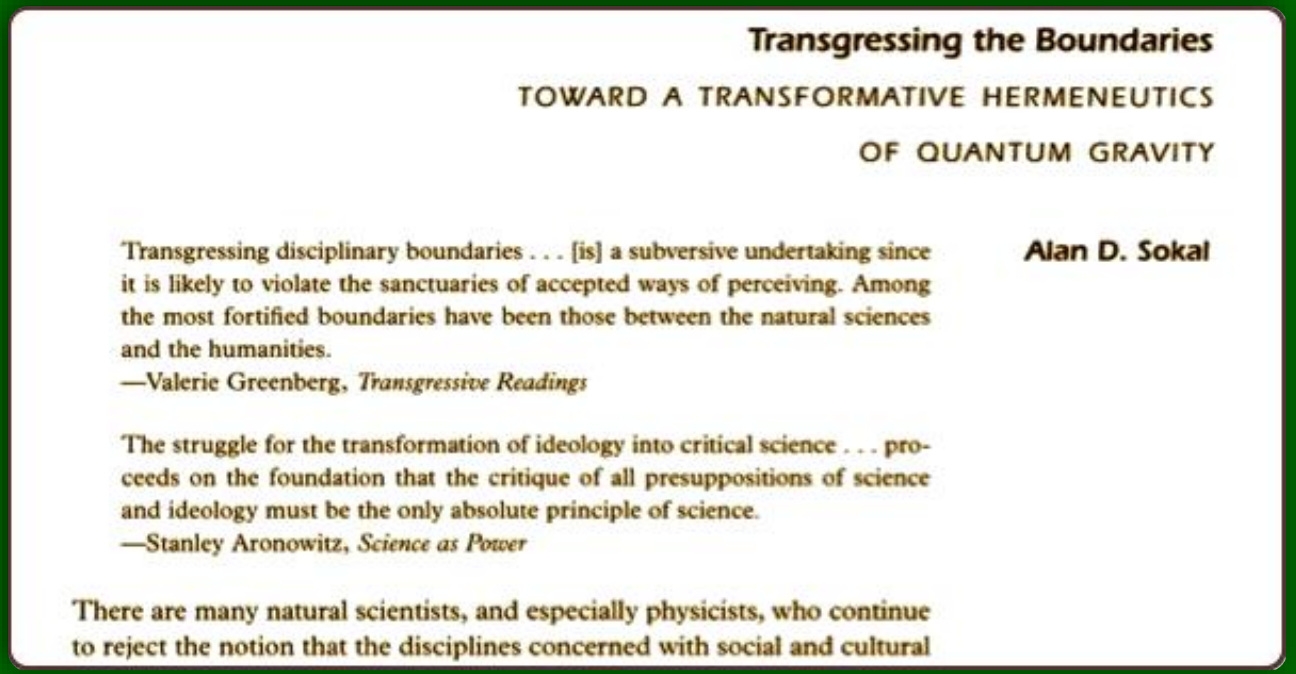
Sokal affair

Alan Sokal
*1955, professor of physics at New York University (NYU)

Sokal, A., Transgressing the Boundaries: Towards a Transformative Hermeneutics of Quantum Gravity, *Social Text*, 46/47 (1996) 217

accepted 1994-11-28, revised 1995-05-13, published 1996-05-XX

confession
: A Physicist Experiments With Cultural Studies, *Lingua Franca*, 4 (1996) 62



Transgressing the Boundaries

TOWARD A TRANSFORMATIVE HERMENEUTICS OF QUANTUM GRAVITY

Alan D. Sokal

Transgressing disciplinary boundaries . . . [is] a subversive undertaking since it is likely to violate the sanctuaries of accepted ways of perceiving. Among the most fortified boundaries have been those between the natural sciences and the humanities.
—Valerie Greenberg, *Transgressive Readings*

The struggle for the transformation of ideology into critical science . . . proceeds on the foundation that the critique of all presuppositions of science and ideology must be the only absolute principle of science.
—Stanley Aronowitz, *Science as Power*

There are many natural scientists, and especially physicists, who continue to reject the notion that the disciplines concerned with social and cultural

prior to confession, **no negative** response

journal **failed** peer-review
: *ms* were read only by editors

papers published based on
person of author & sounding, not the **correctness** or **meaningfulness**

: **Igor** – semiologist, theoretical physicist
: **Grichka** – mathematician
: **Yourievitch Osten-Sacken-Bogdanoff**
:: *1949, Ph.D. University of Burgundy, France

affair of Bogdanov brothers

6 articles in peer-reviewed journals (e.g. *Annals of Physics* & *Classical and Quantum Gravity*)
: *de facto* only two were „original“ – the rest were variation of the two
: soon other scientists find their work fallacious (Max Niedermaier (2002), Urs Schreiber (2004), ...)

fictive institute and **internet address** in Riga (www.phys-maths.edu.lv)
: Mathematical Center of Riemannian Cosmology (MCRC)
fictive collaborator
: professor L. Yang, Hongkong

Dec 2004, cause **Bogdanovs** vs journal ***Ciel et Espace***
: Bogdanovs were found guilty in year 2006 to pay court costs (2500 EUR)
:: they never appeared during the trial

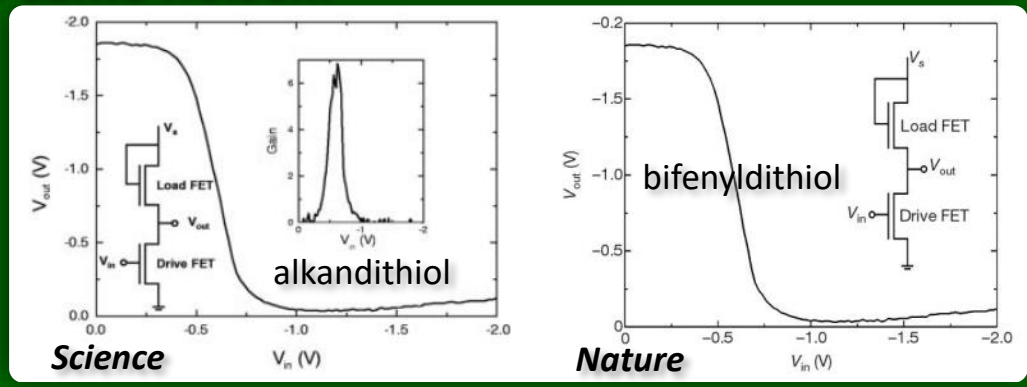
public condemnation for overwriting **wikipedia** entry for their own good
: in France they continue in successful ☹ engagement in science & its popularisation
:: professors on Универзитет Мегатренд (2005), TV show *À deux pas du futur* (2010)
:: book *Avant le Big bang : La création du monde* (2004) – 4.3☆ amazon.fr

Jan Hendrik Schön *1970, Ph.D., Bell Labs

Otto-Klung-Weberbank in physics 2001, Braunschweig prize 2001 & Outstanding Young Investigator Award of the Materials Research Society 2002

discovery and construction of **transistor on molecular level**

briefly after publication the negative response
: anomalies in data, too precise data, different data had the same noise...
: same graph, different publications @ different conditions



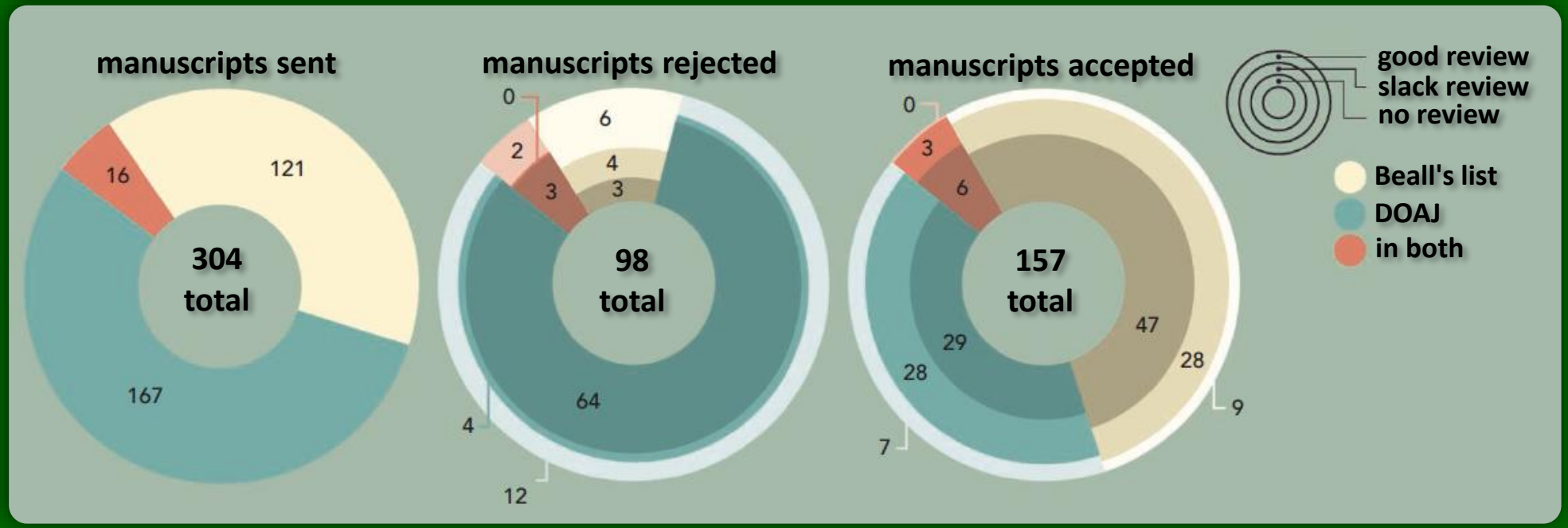
25 suspicious articles with 20 co-authors
: **prestigious journals** *Nature*, *Science*
: in 36 cases, **the frauds were confirmed**
: **none** of **co-authors was accused** (even his boss Batlogg)
: **papers are still cited** as evidence (work retracted in 2001 from Nature 37x !)

since 2004 revision on his Ph.D. & DFG relation (banned to apply for grants)
: 2009 title revision approved by university authorities, 2010 lawsuit with university
:: **local court** reversed decision of the university
: 2011 **state court** & 2013 **federal administrative court** recognized decision of the university
: 2014 **federal constitutional court** finally recognized decision of the university; title taken

who's afraid of peer review?
: Science 2013

fictive authors
: e.g. Ocorrafoo Cobange, Wassee Institute of Medicine, Asmara, Eritrea

molecule X of lichen of Y specie inhibits growth of cancer cells type Z
: database of X, Y & Z + programme à la MadLibs in Python
:: D. Aguayo, M. Krohn, J. Stribling – **SCIgen + SCIpher** (2005); 85 papers went through



DOAJ – directory of open access journals

Alan Sokal pointed out on questionable publishing
: 1996 – Transgressing the Boundaries : Towards a Transformative Hermeneutics of Quantum Gravity

James Lindsay, Helen Pluckrose & Peter Boghossian tried it again
: 2018 – 20 fake papers of fashionable jargon & ridiculous conclusions tried to high-profile journals
:: fancy fields including gender or obesity studies
:: 4 get published, 3 accepted, 4 under review and 9 rejected
:: debunked by media (*The Atlantic*, *NYT* and *the Economist*)

: it received mixed reactions
:: praise for exposing the weakness of scientific media for sensational anti-system articles
::: *Stars, Planets, and Gender: A Framework for a Feminist Astronomy*
::: *Super-Frankenstein and the Masculine Imaginary: Feminist Epistemology and Superintelligent Artificial Intelligence Safety Research*
:: criticism for non-scientific approach & pointlessness
::: as an experiment it was poorly designed, at least there were no controls
::: peer review can hardly discover fraud, unless there are flagrant discrepancies in the paper

high profile nanomaterial scientist at Palacký University of Olomouc

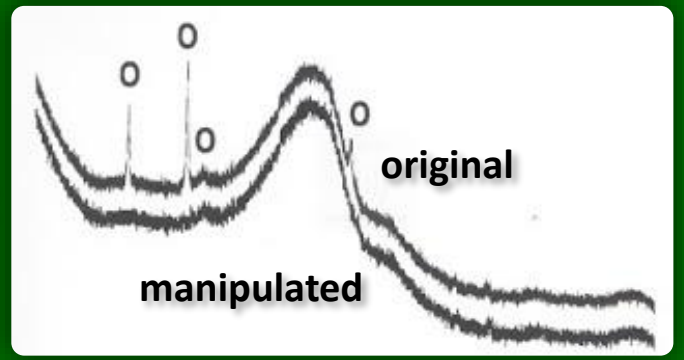
: The Regional Centre of Advanced Technologies and Materials (RCPTM)

: H-index > 60, one of the most cited researchers in Czechia

: spectra manipulation in his 2007 *JACS* article revealed by student in 2012

:: it was ignored and the student has failed defence (7 negative)

:: new defence in 2013 again failed (2 positive, 2 negative, 2 invalid)



: new dean in 2018 started the process of re-evaluation of the 2012 revelation

:: fraudulent behaviour was found with the highest possible probability

:: dean submitted it to rector and he to ethical committee, which agreed with the previous findings

:: JACS refused errata offered by authors and retracted the paper

: new manipulation with data was found in 2016 *Nature Communication* paper in 2019

:: errata submitted contained another picture manipulation

::: questionable defence of the authors vs rigorous arguments of the opponents

:::: mathematical analysis of the noise in new spectra showed that they were manipulated

:::: internal fight lead by powerful clique of bosses of research centre against faculty

:::: ethical committee chair resigned in a protest (being falsely accused of fraud)

unfortunately, this sad show is still going on due to absence of an independent, third-party evaluation

difference between different publication affairs?

Schön & **Bogdanovs** & **Zbořil** & **Sokal's epigones** (and probably **Bohannon** too) were **exposed**
: not due to reviews, but application of scientific method (reproducing & critical analysis)
:: self-correcting tendencies in science

Sokal wouldn't be exposed, if he did not confess
: pseudo-science only piles texts & concepts without possibility to test them
:: PS. philosophy needs necessarily not to be pseudo-science

negligible sanctions for a wrong review lead to slack reviews

manipulations in peer-reviewed journals
: „forthcoming“ editors – choice of reviewers, ignoring legitimate objections
: private companies – co-ordinating fraud processes
:: starting with innocent help to authors (proof-reading)
:: up to ghost writing of manuscripts from preforms
and manipulated contact lists for reviewing process
(true names of offered reviewers, fake contacts)
:: corrupting journal editors under false pretend of helping the new authors
:: direct attempts to buy the publishing (sometimes with threats)

paper mills

: commercial institutions producing fraudulent papers on demand

:: an agent mediates between the customer and the mill

:: 14 800 USD for first-author paper in *Int. J. of Biochemistry & Cell Biology*

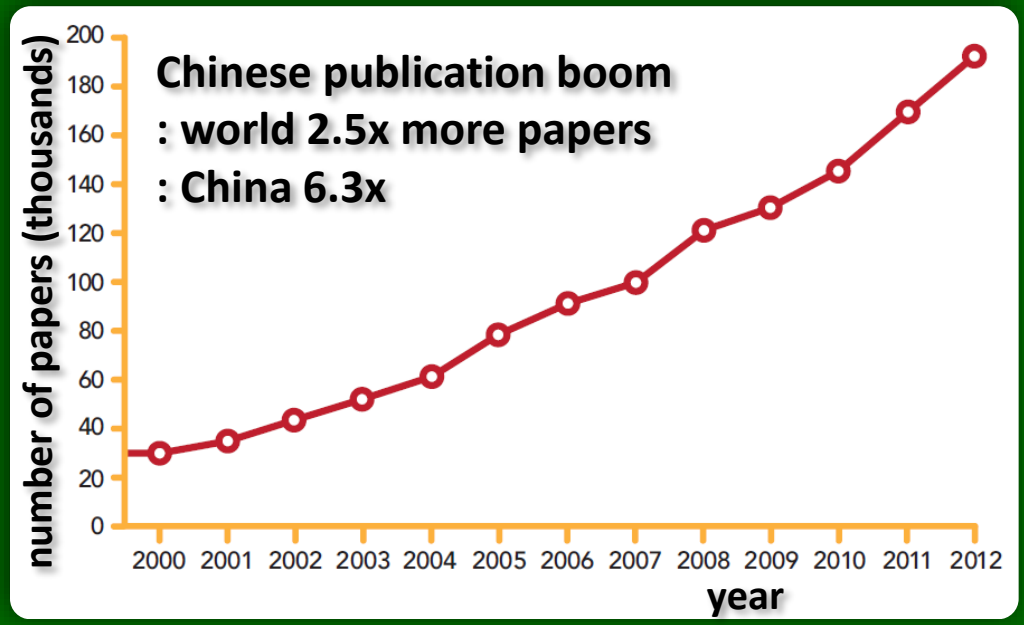
::: two particular co-authors 26 300 USD

:: from contract to publication – few weeks

:: after making it public, the company denied everything

: up to 27 suspected companies on the Chinese market

:: *people are sparing no expenses in order to get published in SCI* – one of the customers



: **blog**
:: retractionwatch.com
:: since Aug 2010, I. Oransky, A. Marcus

retraction watch

: **informs about malpractice**
:: retracted articles
::: mistake vs fraud
:: publishing fraud
:: publishing misconduct

: **Scott S. Reuben**
:: 21 articles retracted
:: sentenced
::: 3 years of supervised release
::: 400 000 USD to pay

: **Gregg L. Semenza**
:: picture manipulation
:: Nobel prize (2019)

: **self-correcting processes in science**
:: to cheat is worth only for a short term
:: up to 100% chance to be discovered

replication crisis

: **dark side of fighting the unethical publishing**
:: blackmailing authors under the pretext of revising articles
:: predatory companies pretend to be guardians of research integrity

predatory journals

: email with flattery, e.g. how damn significant they found one of your papers
:: irrelevant, often it is your fresh paper with no citations
: proposal to publish in a special issue or even editing it
:: *pseudo-open access*, misusing the idea of open publishing
: after acceptance (without review) follows an info on high price to be paid
:: regarding some unannounced service
: more ethics violations
:: editorial board without their consent, false identity (ISSN)
: **Beall's List** (https://beallslist.weebly.com)
: **Stop Predatory Journals** (https://predatoryjournals.com)
: **The Journal Blacklist**, Cabells (paywall; 2019 – 12 000 records)

predatory conferences

: email asking you to give a lecture on „an important“ conference
:: importance is fictive, often obscure location
: generous offer of significant discount (*ca* 300 USD)
: thereafter hefty bill comes (*ca* 1600 USD)
: misleading homepage
: *OMICS Group, Coltharp Institute*...

predatory practices

cure for predatory practices

: publisher's honesty
: honest business practices
: transparency of processes

commercialised science

: decisive are pseudo-objective criteria, not an experienced opinion
:: tends to reduce the personal interests, but is forced into line (fashion)
::: tit-for-tat, subconscious siding with people with the same opinions

: permanent (tenure) vs temporary job
:: modern feudalism

: grants go the old guard, the young often get nothing

: opportunists/careerists often do science, who seek glory and power
:: in science it works only by making progress – in small steps

its connection to state

: need for large investments leads to new sources
:: state or private sector
:: power ennobles, absolute power ennobles absolutely

: science is hired
:: controlled by immediate political & economic interests
::: political and industrial lobby

postmodern plurality of theories

: reassessment of what it means that the theory meets experiment

:: „invisibility“ of quark

... [hypothesis infirmation] is some kind of papal trial, a popperazzi, about what science is and what not ...

Leonard Susskind

syndrome of the only game in town

(book by Kurt Vonnegut jr.)

: actual situation in particle and theoretical physics

:: combining pop-science with difficulties to find alternatives to it

: consequences

:: scientific mafia propagating pop-science and supressing alternatives

:: the old guards sitting on concepts and money

::: before 1970 professor age median was 40, in 2002 it is already 60

::: only *ca* 1/8 with Ph.D. get job in their field

story of the book *Not even wrong by* Peter Woit

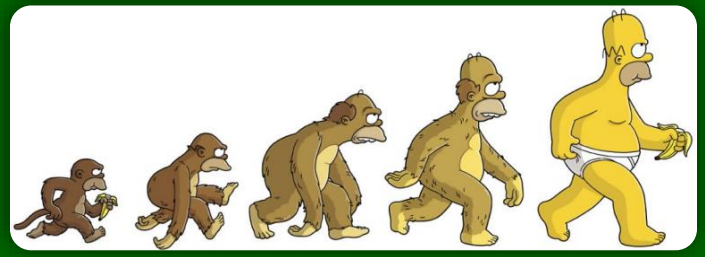
: intentionally negative reviews & absence of will to accept criticism (Luboš Motl)

science reception by general public

not to explain vs **to explain incorrectly**
: major mistake of science critics (god of the gaps)
:: where is no explanation, there is a gap for „a god“

sources of **scepticism** & **disbelieve** towards science

: **incompleteness** of knowledge
: its **negative consequences**
: **unintelligible language** of science
: **subjective** insecurities & nesciences



scientists are unable to admit things they are unable to explain

often **disillusion** in general public, who **expected** something of science, what was **not fulfilled**, and they thus somehow conclude, that **science becomes obsolete** and that scientific way of studying should be **substituted by something else**

confusing changes in a paradigm
: scientific models of reality take place out of our everyday experience
:: they change relatively fast & the level of understanding decreases

: a wrong map is better than no map at all

main source of problems
: **scientific illiteracy**
:: among laymen (non-scientists)
:: but also experts (not only from humanities)
→ **alienation** of science, their results and scientists in society