MODELING;
AN INTRODUCTION

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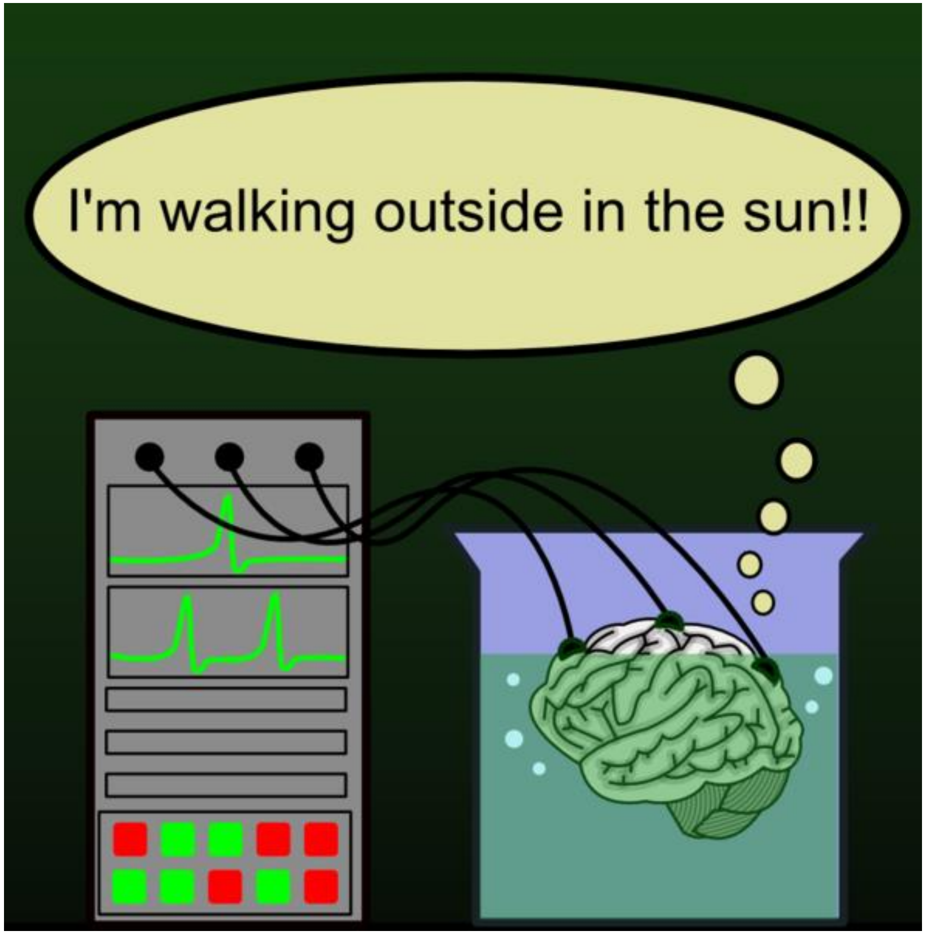
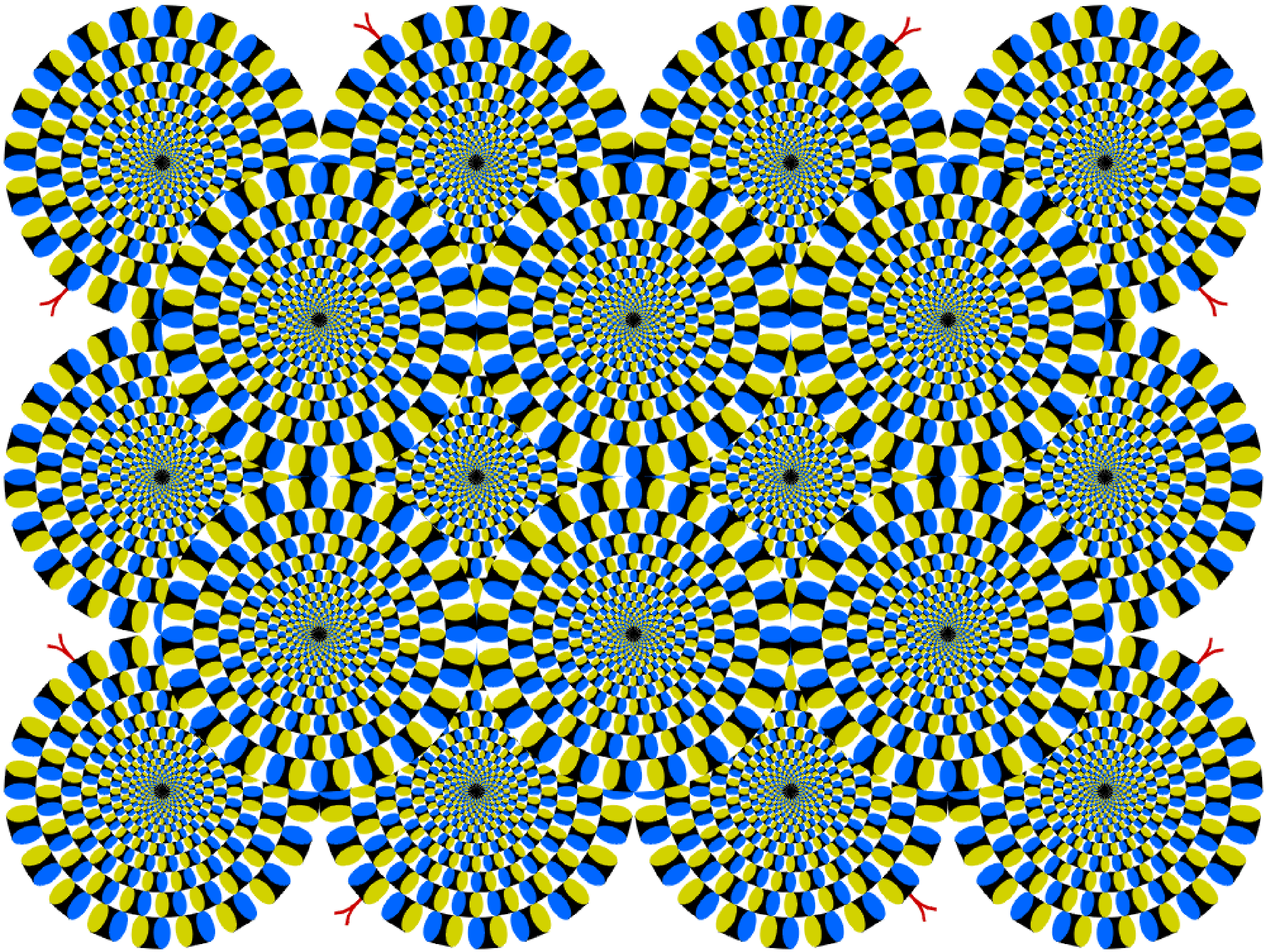
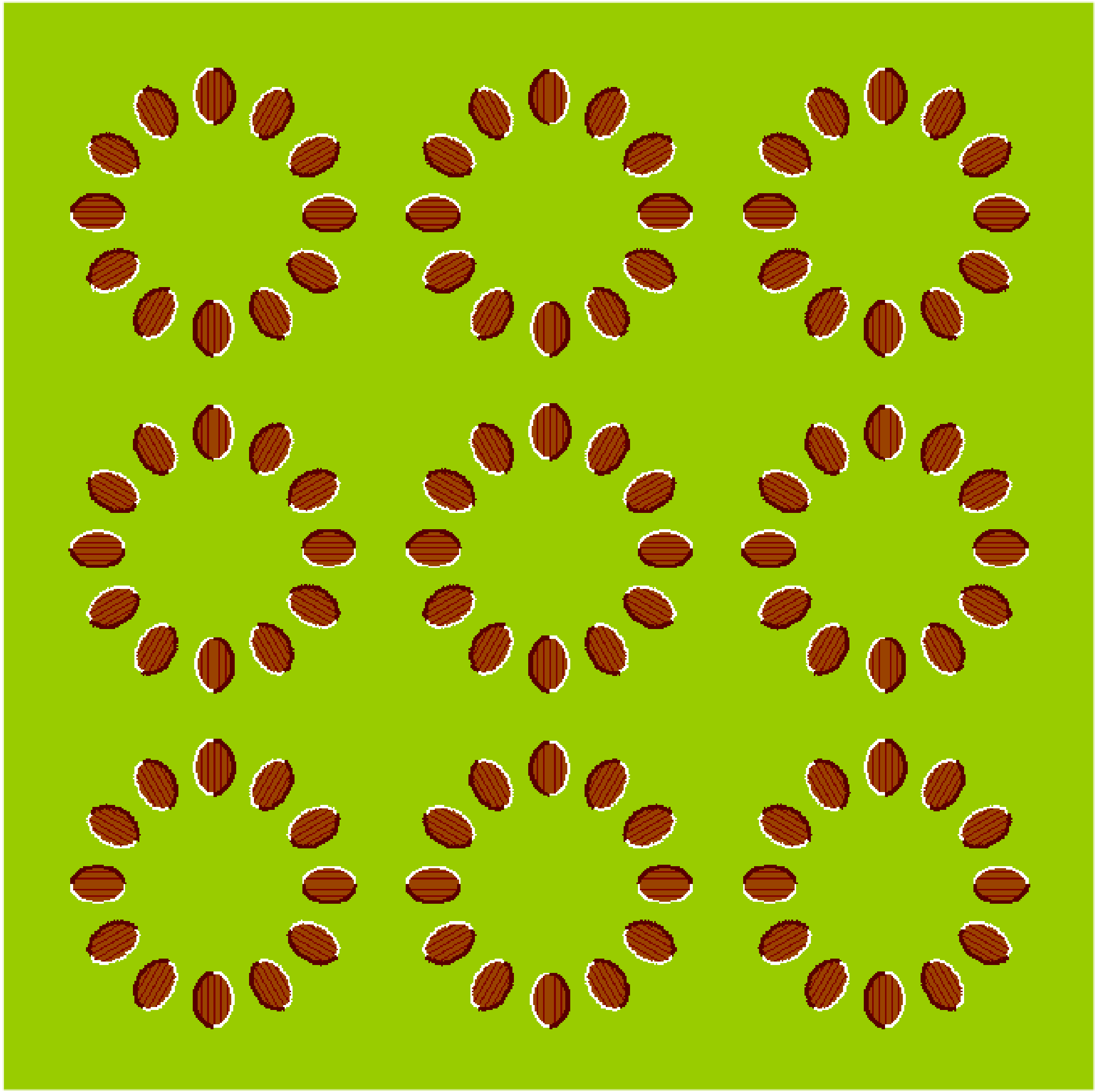
Reality



What is the reality?



What the scientists do?



Unifi

http://constructortheory.org/

A Model?

- *In his 1973 book "Allgemeine Modellltheorie" (General Model Theory) Herbert Stachowiak describes the fundamental properties that make a Model.*

Fundamental Model Properties

- **Mapping**: Models are always models of something, i.e. mappings from, representations of natural or artificial originals, that can be models themselves.
- **Reduction**: Models in general capture not all attributes of the original represented by them, but rather only those seeming relevant to their model creators and/ or model users.
- **Pragmatism**: Models are not uniquely assigned to their originals per se. They fulfill their replacement function a) for particular – cognitive and/ or acting, model using subjects, b) within particular time intervals and c) restricted to particular mental or actual operations.

Mapping

- Such originals can evolve in a natural way, be produced technically or can be given somehow else. They can belong to the areas of symbols, the world of ideas and terms, or the physical world. […] Actually, every entity, that can be experienced (more general: ‘built’) by a natural or mechanical cognitive subject, can in this sense be considered an original of one or many models. Originals and models are interpreted here solely as attribute classes [representable by predicate classes], that often achieve the shape of attributive systems [interrelated attributes that constitute a uniform orderly whole]. The concept of mapping coincides with the concept of assigning model attributes to original attributes in the sense of a mathematical (set theoretical, algebraic) mapping.

Reduction

- To know once that not all attributes of the original are covered by the corresponding model, as well as which attributes of the original are covered by the model, requires the knowledge of all attributes of the original as well as of the model.
- This knowledge is present especially in those who created the original as well as the model , i.e. produced it mentally, graphically, technically, linguistically, etc in a reproducible way.
- Only then an attribute class is determined the way intended by the creator/ user of the original and the model.
- Here, an attribute class is an aggregation of attributes of the original as well as of the model side, out of the overall unique attribute repertoire. Thus, the original-model comparison is uniquely realisable. […]

Pragmatism

- Beyond mapping and reduction the general notion of model needs to be relativized in three ways.
  - Models are not only models <u>of something</u>.
  - They are also models <u>for someone</u>, a human or an artificial model user. At this, they fulfil their function <u>over time</u>, within a time interval.
  - Finally, they are models <u>for a certain purpose</u>.
- Alternatively this could be expressed as: a pragmatic complete determination of the notion of model has not only to consider the question '<u>what of</u>' something is a model, but also '<u>whom for</u>', <u>when</u>, and '<u>what for</u>' it is a model, wrt. its specific function.

Source

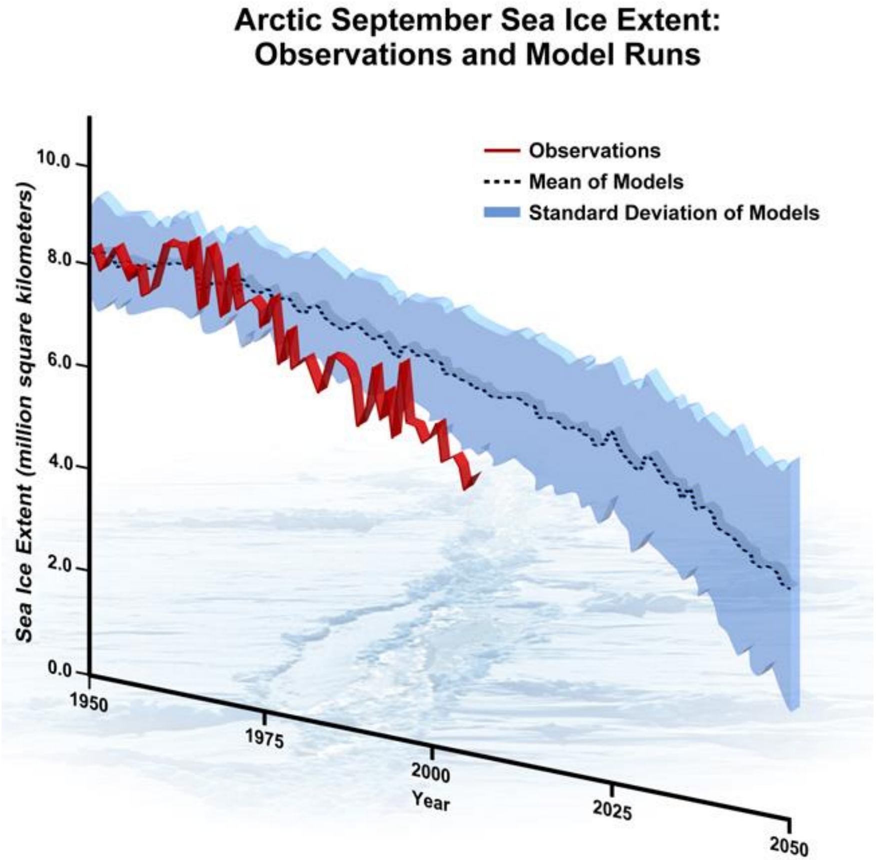
- Stachowiak, Herbert (1973) (in german (DE)). *Allgemeine Modelltheorie [General Model Theory]*. Springer. ISBN 3-211-81106-0.

MODELING OBJECTIVES

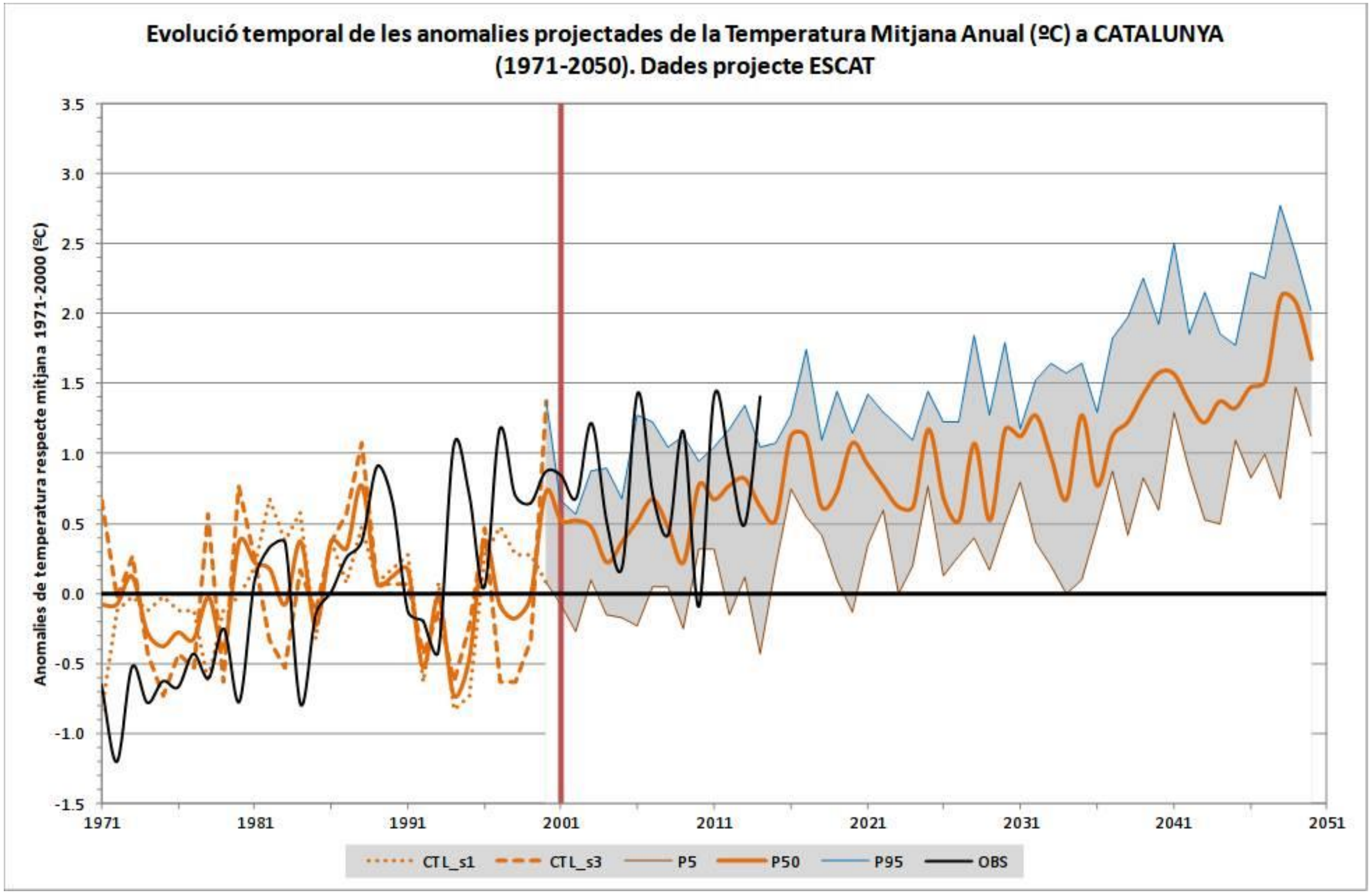
- Evaluating system performance under ordinary and unusual conditions
- Predicting the performance of experimental system designs
- Ranking multiple designs and analyzing their tradeoffs
  - Answer What If Questions
  - Support Decision Making

As an example

- Climatic change

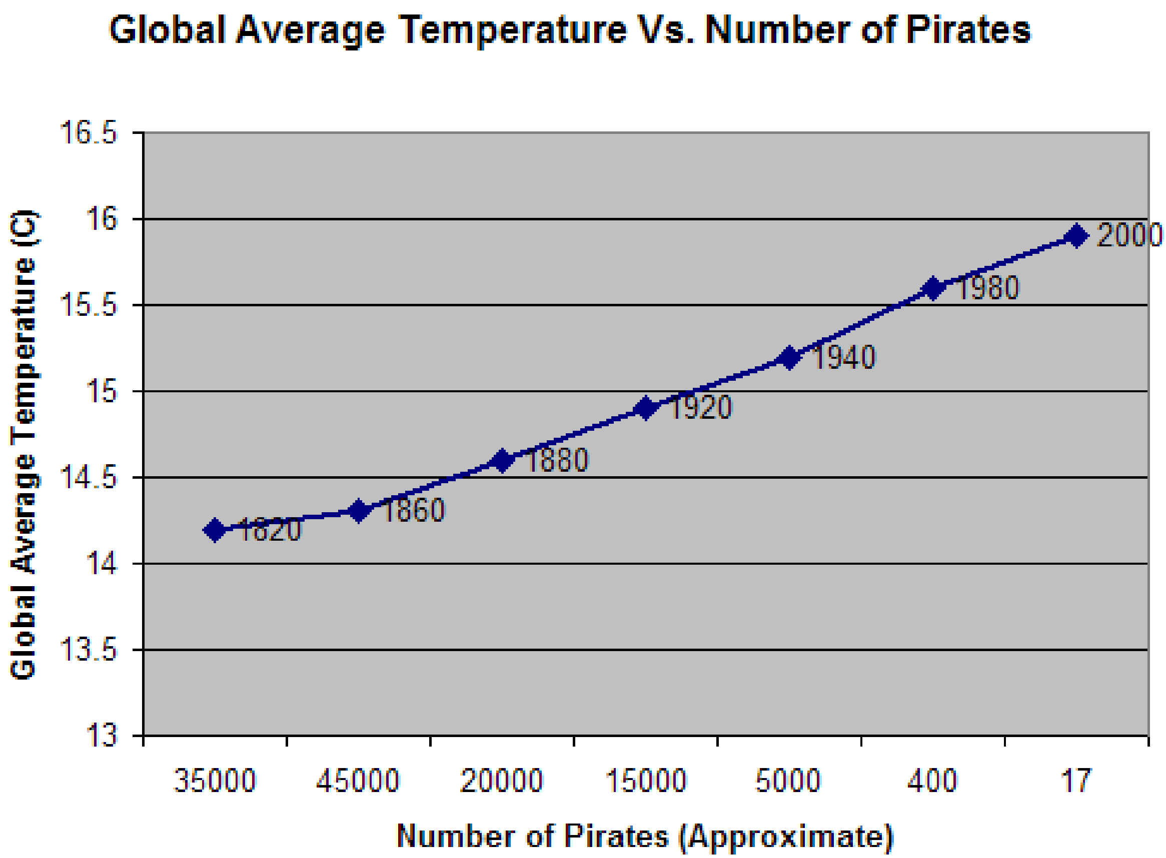


Temperature projection for CAT (2050)



But…

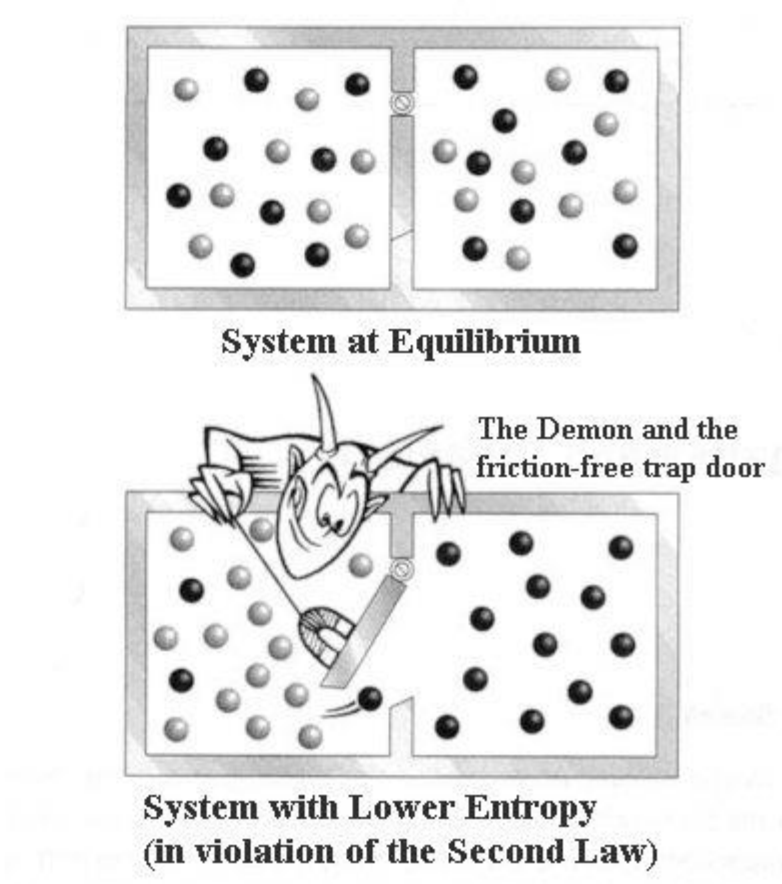
- Definitivaly, it is not to easy…



Models

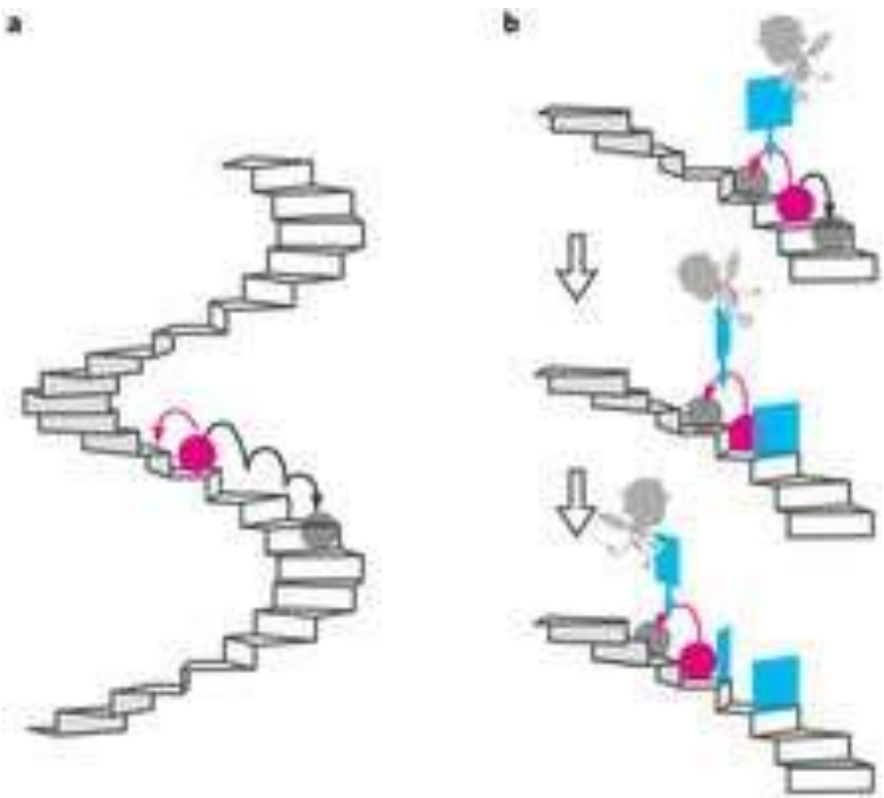
Any kind of models.

Models, experiments...



- Maxwell's demon
- Source: http://universe-review.ca/R01-02-z1-information.htm

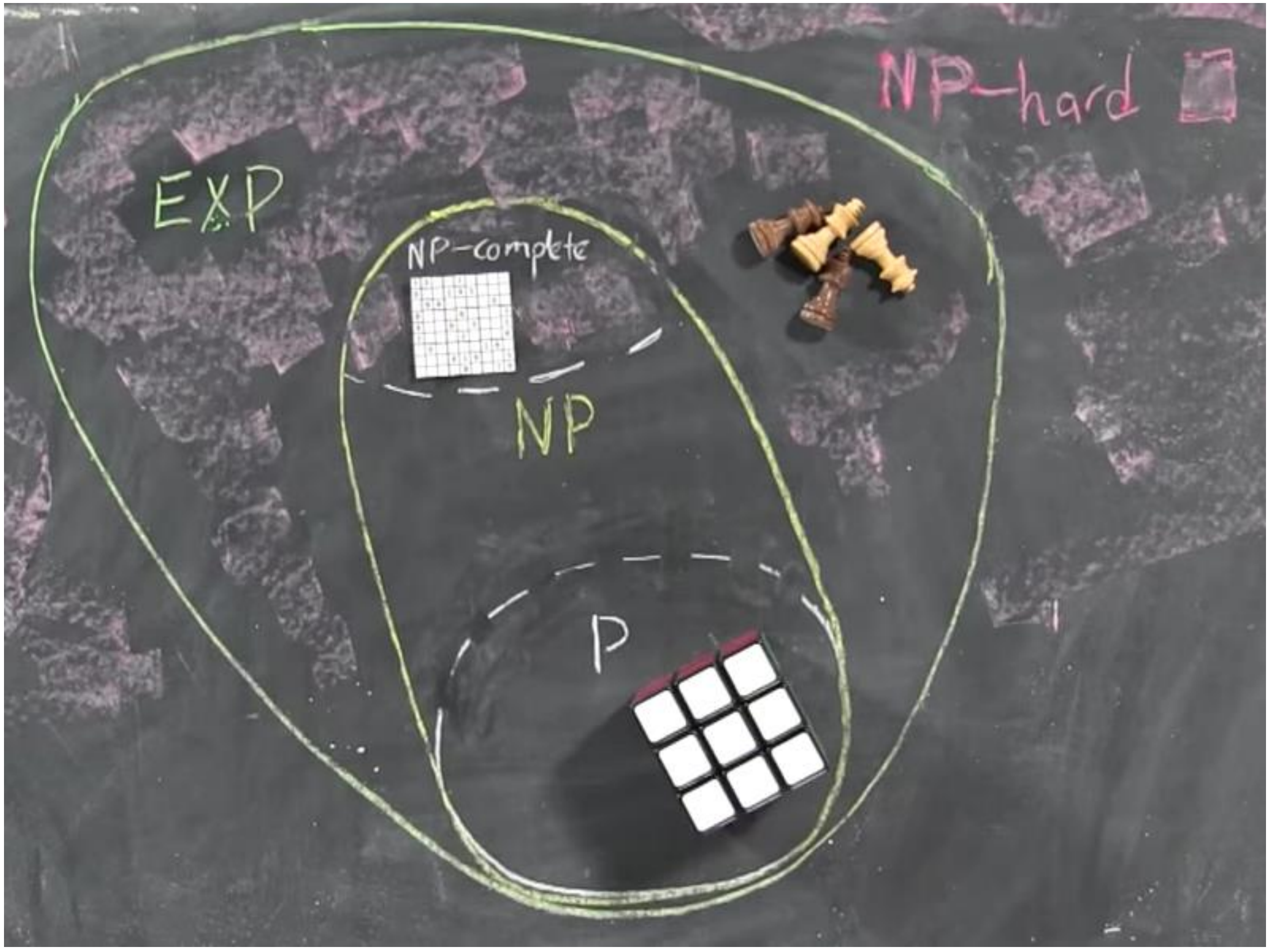
Maxwell's demon demonstration turns information into energy



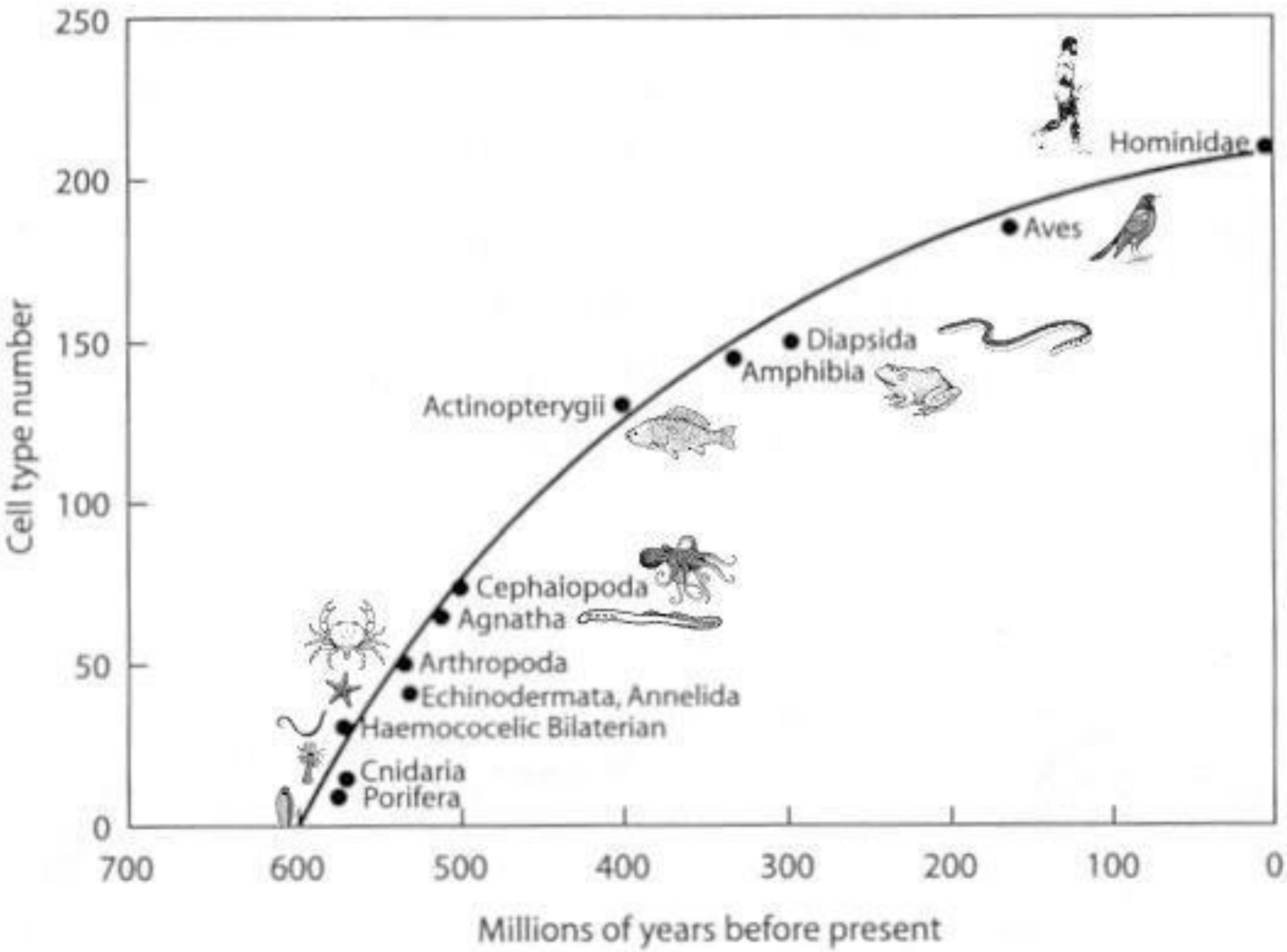
Schematic illustration of the experiment. For more details, see the original publication. Image credit: Nature Physics, doi:10.1038/nphys1821

Read more at: https://phys.org/news/2010-11-maxwell-demon-energy.html#jCp

Complexity



Complexity



Cell type number
250
200
150
100
50
0
Hominidae
Aves
Diapsida
Amphibia
Actinopterygii
Cephalopoda
Agnatha
Arthropoda
Echinodermata, Annelida
Haemococelic Bilaterian
Cnidaria
Porifera
700
600
500
400
300
200
100
0
Millions of years before present

Complexity

System	Structure	Alphabetical Arrangement	Natural System	Order	Information
Randomness	random	HSIA TESHO SR I	molecules in the air	none	none
Order	periodic	HHHHHHHH HHH	crystal	lot	none
Complexity	aperiodic	HORSE THIS A IS	Nucleotides C, T, A, G	some	some
Specified Complexity	aperiodic	THIS IS A HORSE	Viable genes to produce proteins	lot	lot

Complexity

Complexity As	Definition	Example(s)	Problem
Size	Larger size means higher complexity	Size of body or genome	Some simple organisms have larger genome size than human's
Entropy	More variation signifies more complex message	HHH… has no variation and zero entropy, the random sequence DXW… has lot of variation	The most complex object is in between most orderly and complete randomness
Algorithmic Content	Shorter computer program to describe the object corresponds to lesser complexity	HHH… requires very short description, garbled message cannot be compressed	Random object leads to high information content
Logical Depth	Complexity is measured by how difficult to construct the object	HHH… is very easy to construct, while a specific message requires more work	It is difficult to measure the difficulty
Fractal Dimension	Higher fractal dimension equals to higher complexity	The coastal line is more complex than a straight line	There are other kinds of complexity not defined by fractal dimension
Degree of Hierarchy	Complexity is equated to the number of sub-systems	Organ to cells to organelles to macro-molecules to …	It is difficult to separate the whole into parts

Kind of models

- Deterministic models
  - Differential equation
  - Linear Programming (Simplex algorithm)
- No deterministic models
  - **Statistical models**
  - **Queuing models**
  - Markov models
  - Monte Carlo simulation models
  - **Discrete simulation models**
  - Continuous simulation models

AN AD HOC MODEL CLASSIFICATION

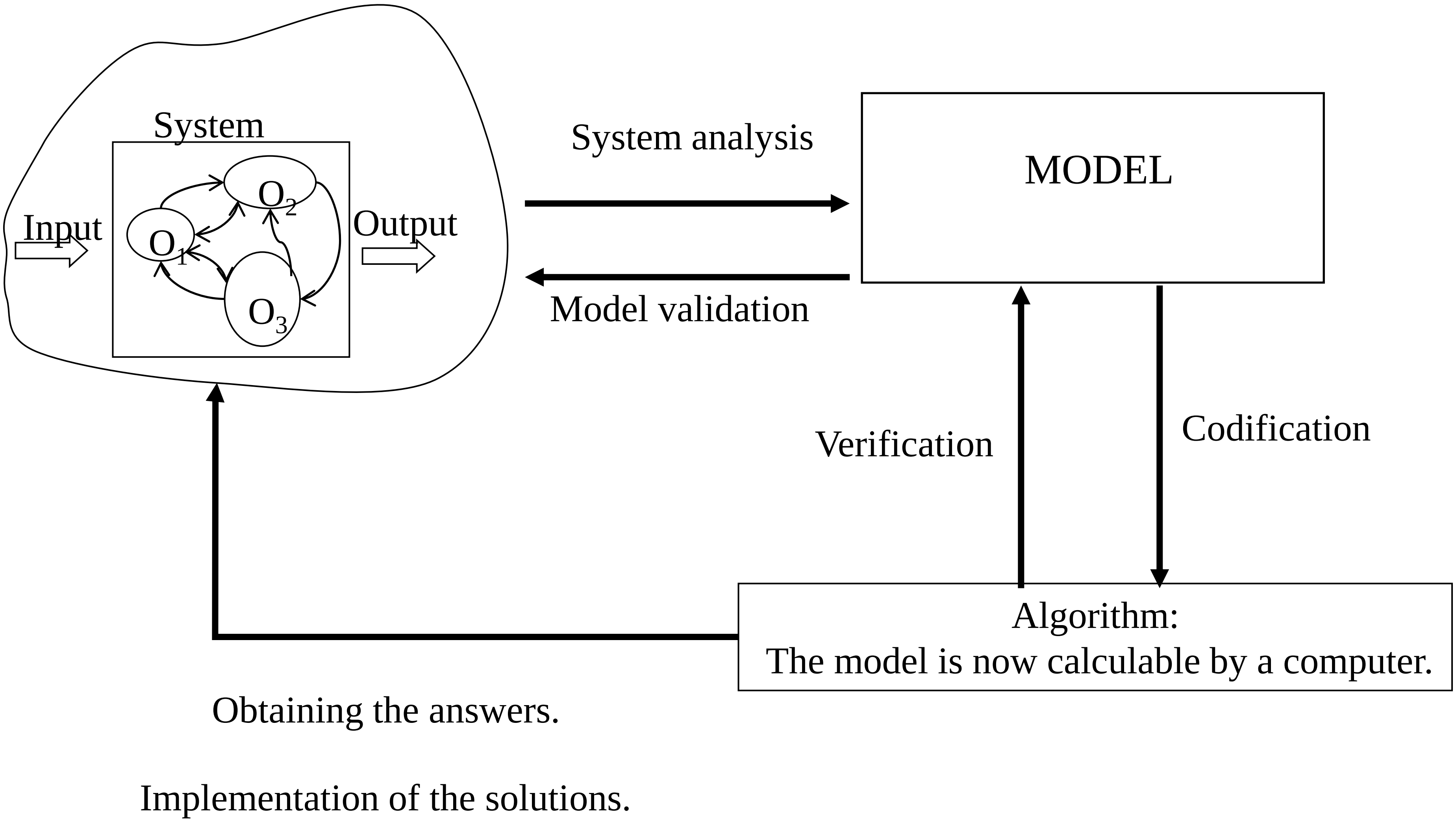
MODELS

- STATIC
  - CONTINUOUS $\Rightarrow$ Min $f(x)$ $\quad f(x): R^n \rightarrow R$
    - $g(x) \leq b, g(x): R^n \rightarrow R^m, b \in R^m$
    - $x \in X \subseteq R^n$
  - DISCRETE $\quad x \in Z_+^n \quad \left(\text{or } x \in \{0,1\}^n\right)$
- DYNAMIC
  - CONTINUOUS $\rightarrow$
    - Differential Equations
    - Difference Equations
  - DISCRETE $\rightarrow$ SIMULATION

Statistical model

- Mainly a formalization of the existing relationships between system variables in the form of a mathematical equations.
- Random, because we don't understand all is introduced on the model.
  - The model describes how one (or more) random variables are related to one or more other variables.

Models creation

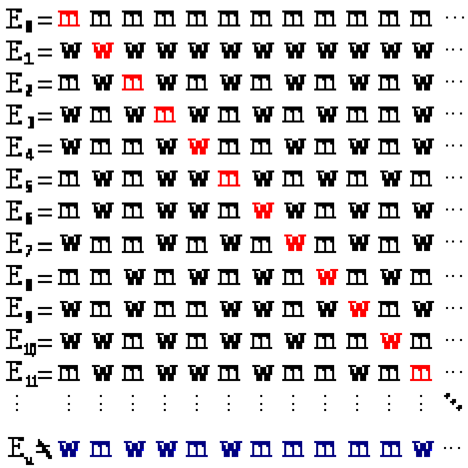


Models are important

- Galileo Galilei
- Johannes Kepler
- Sir Isaac Newton
- Max Planck
- Albert Einstein
- Werner
- Niels Bohr
- Erwin Schrödinger
- Stephen Hawking

The language are also important

- Pythagoras of Samos
- Aristotle
- Fermat
- Gottfried Leibniz
- Georg Cantor
- Lewis Carrol
- Hilbert
- Gödel
- John von Neumann



And the tool…

- Hero of Alexandria
- Ramon Llull
- Al-Jazari
- Leonardo
- Alan Turing
- George Stibitz

Study main stages

Define and Design

- Write out research questions in theoretical and operational terms
- Design the study or define the design
- Choose the variables for answering research questions and determine their level of measurement
- Write an analysis plan
- Calculate sample size estimations

Prepare and explore

- Collect, code, enter, and clean data
- Create new variables
- Run Univariate and Bivariate Statistics
- Run an initial model

Refine the model

- Refine predictors and check model fit
- Test assumptions
- Check for and resolve data issues
- Interpret Results

Simulism

Elon Musk: 'Chances are we're all living in a simulation'

Billionaire entrepreneur behind Tesla, SpaceX, PayPal and Hyperloop discusses Mars, driverless cars and going into orbit

Elon Musk introducing the SpaceX Dragon V2 spaceship at the SpaceX headquarters in Hawthorne, California. Photograph: Jae C. Hong/AP

Source:

theguardian

https://www.theguardian.com/technology/2016/jun/02/elon-musk-tesla-space-x-paypal-hyperloop-simulation