Looking for Tomorrow's Mainstream

Alexander Gorban

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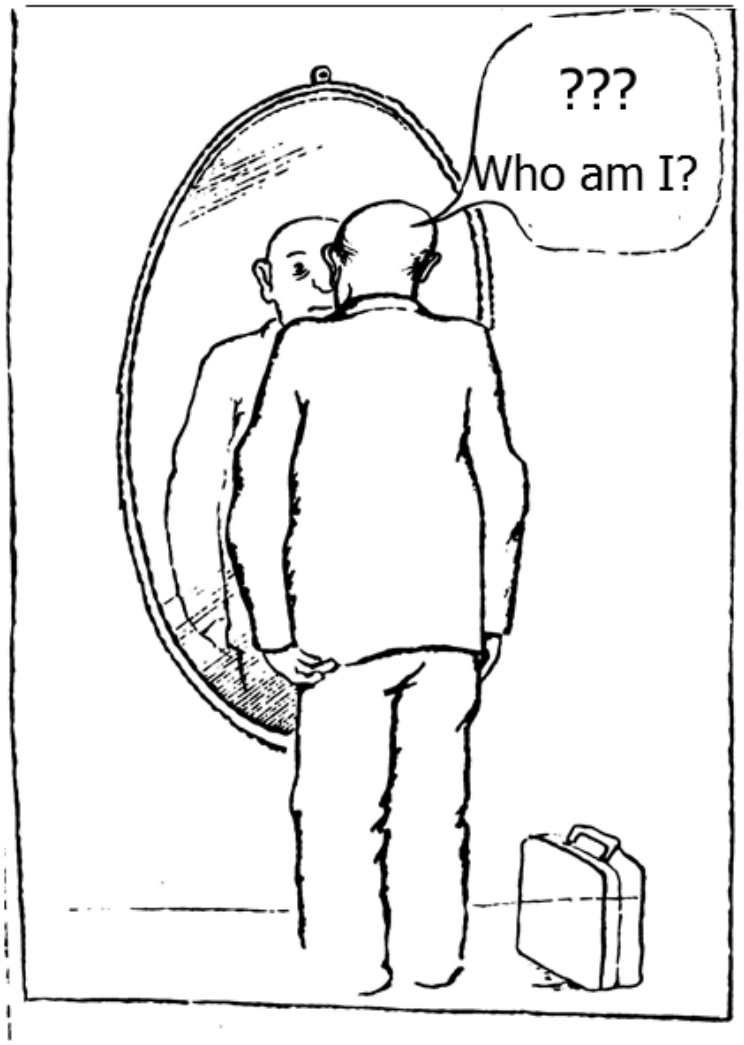
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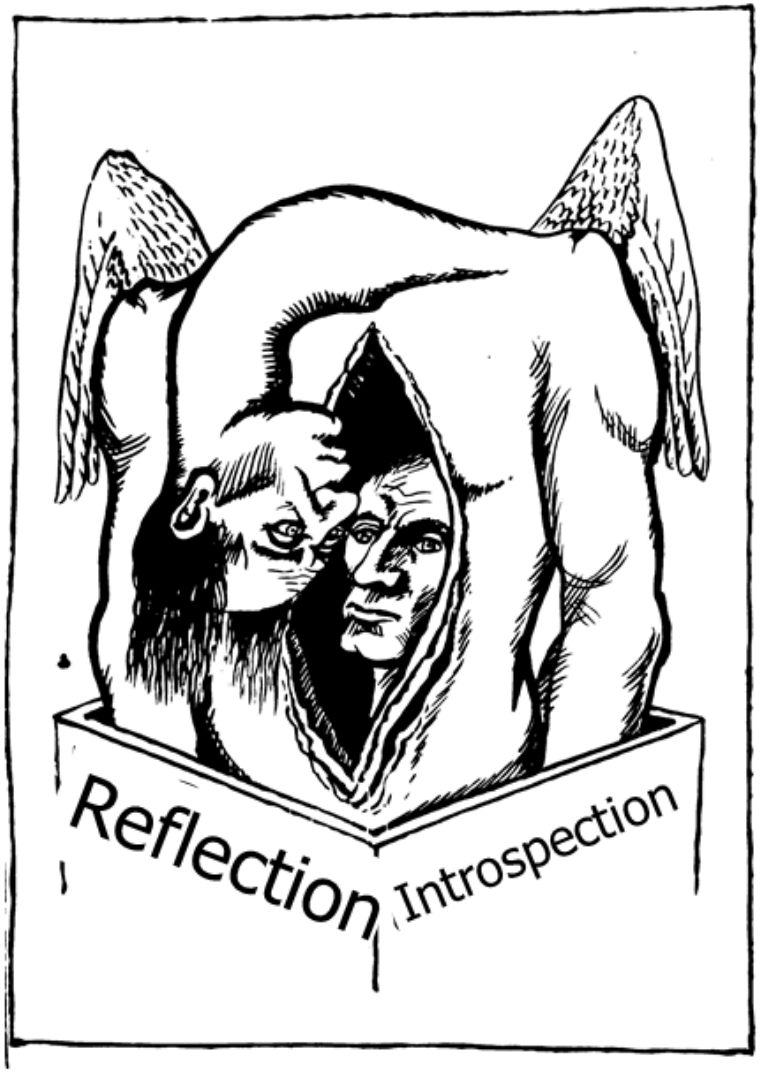
Who am I?


Reflection
Introspection

Looking for Tomorrow's Mainstream

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Plan

- Golden time of play
- A mysterious review
- Mainstream or not Mainstream … ?
- How to measure leadership?
- Past Mainstream or future Mainstream?
- Change of epochs:
  -from the Great Laws discovery
  -to struggle with Complexity

Plan

- Model reduction
- Self-simplification
- Stair of locomotive problems
- Are we crazy to rely on Mathematics, or "the unreasonable effectiveness of Mathematics in the Natural Sciences"
- Acknowledgements

Golden time of play

"Three metamorphoses of the spirit have I designated to you: how the spirit became a camel, the camel a lion, and the lion at last a child." Thus spake Zarathustra.

But first I was a child in science, and I played with pleasure

Golden time of play

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Gautama metamorphoses

His father had ordered that he live a life of total seclusion...

But one day Siddhartha ventured out into the world and was confronted with the reality of the inevitable suffering of life.

But first I was a child in science, and I played with pleasure

A mysterious review

- "… Nothing wrong, but too applied… You can publish for your choice, but it is not mainstream."

A mysterious review

- "… Nothing wrong, but too applied… You can publish for your choice, but it is not mainstream."

!!!!!!!!!!

Mainstream or not Mainstream … ?

How to measure leadership?

- **"Man is the Measure of all Things"-** Protagoras of Abdera (c. 480-410 B.C.)

How to measure leadership?

- **"Man is the Measure of all Things"-** Protagoras of Abdera (c. 480-410 B.C.)
- But this man was tired of measuring of all things, and he (or she?) invented…

How to measure leadership?

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MONEY

Leonardo & Avicenna

Demokrit & Al-Farabi

Kopernikus & Descartes

Gauss & Euler


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Leonhard Euler
1707–1783
Zehn Franken
Dieci Franchi
10

Einstein, Bohr & Schrödinger

Tesla, Faraday, Örsted & Volta

Kelvin & Rutherford

Smith & Marx


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Darwin & Newton

Should we follow the past mainstream?

Just Join

Let us follow this nice road!

Should we follow the past mainstream?

Just Join

Let us follow this nice road!

Change of era

From Einstein's **"flight from miracle."**

«... The development of this world of thought is in a certain sense **a continuous flight from "miracle".**»

To **struggle with complexity**

"I think the next century will be the century of complexity."

Stephen Hawking

Flight from miracles to simple and beautiful laws

Known Laws, beautiful and simple

A miracle:
A phenomenon that contradicts the known laws, to the best of our knowledge.

New Laws, beautiful and simple

The flight from the miracle

Our past mainstream

Struggle with complexity

A phenomenon

Basic Laws, beautiful and simple

A model is a device that works, Applied mathematics becomes ***MODEL ENGINEERING***, Applied mathematicians are ***MODEL ENGINEERS***

A complex model that follows the basic laws, but **does not work**, and we **believe** it is true

A model that **works**

The struggle with complexity

Our future mainstream

Change of era

From Einstein's **"flight from miracle."**

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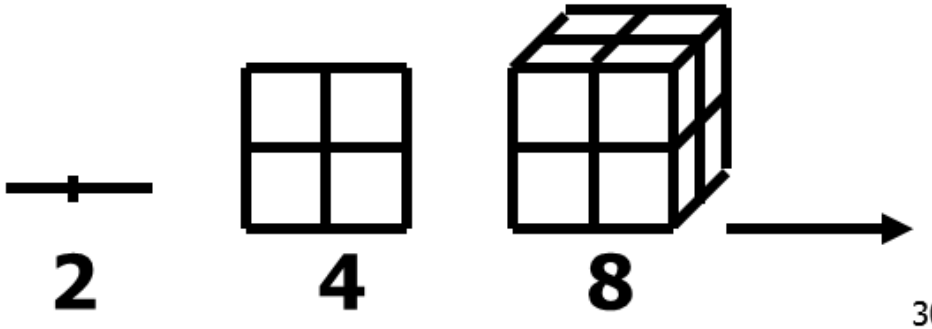
What does it mean: "the complex model?" Curse of dimensionality

Curse of dimensionality (Bellman 1961) refers to the exponential growth of complexity as a function of dimensionality.

And what to do if dim>1000?



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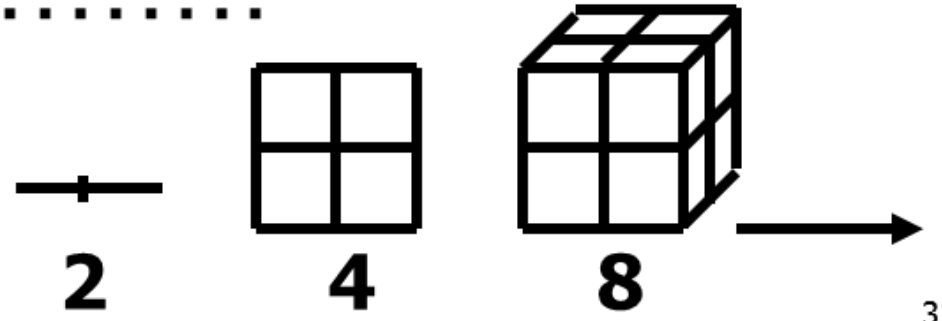
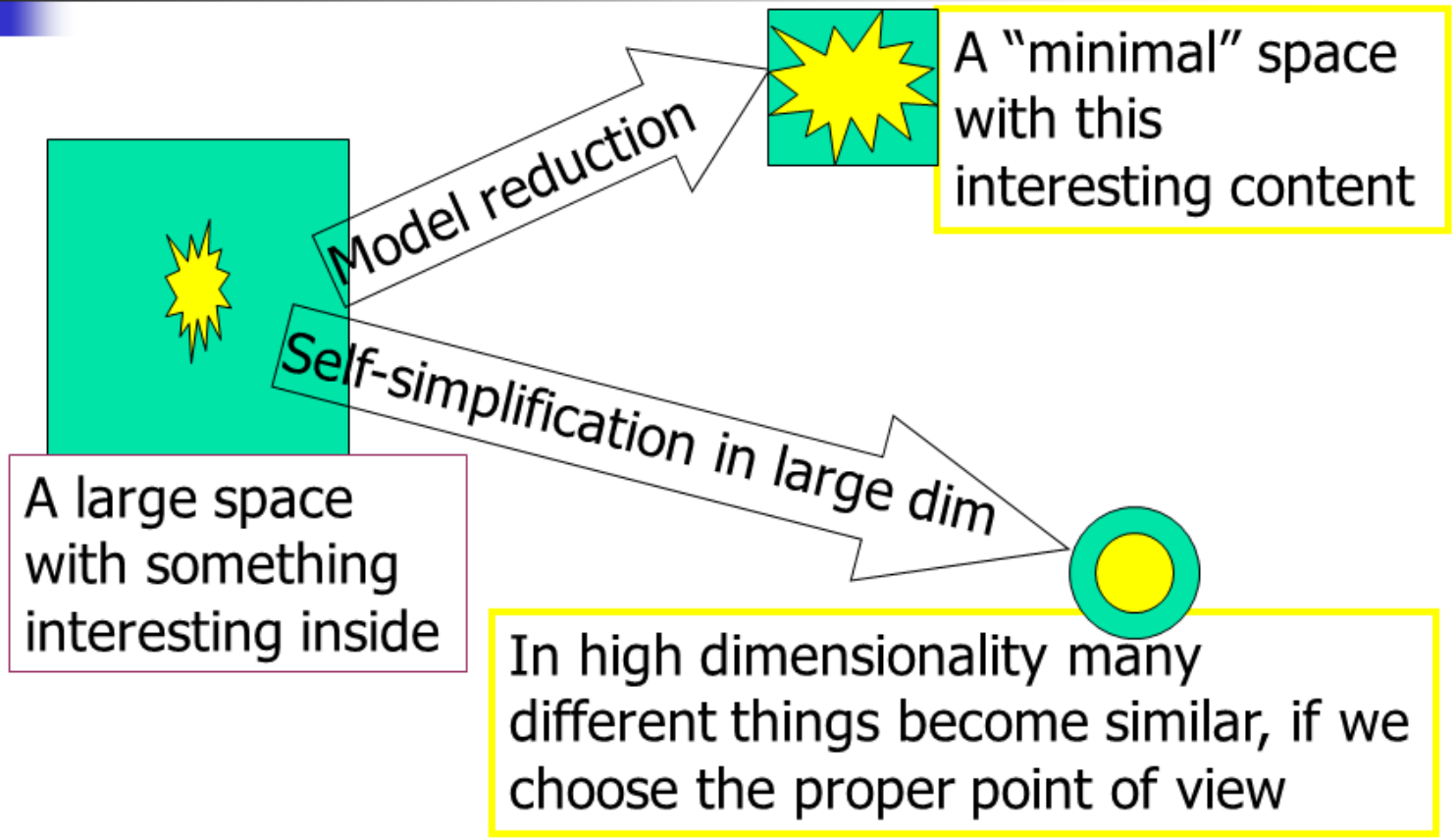
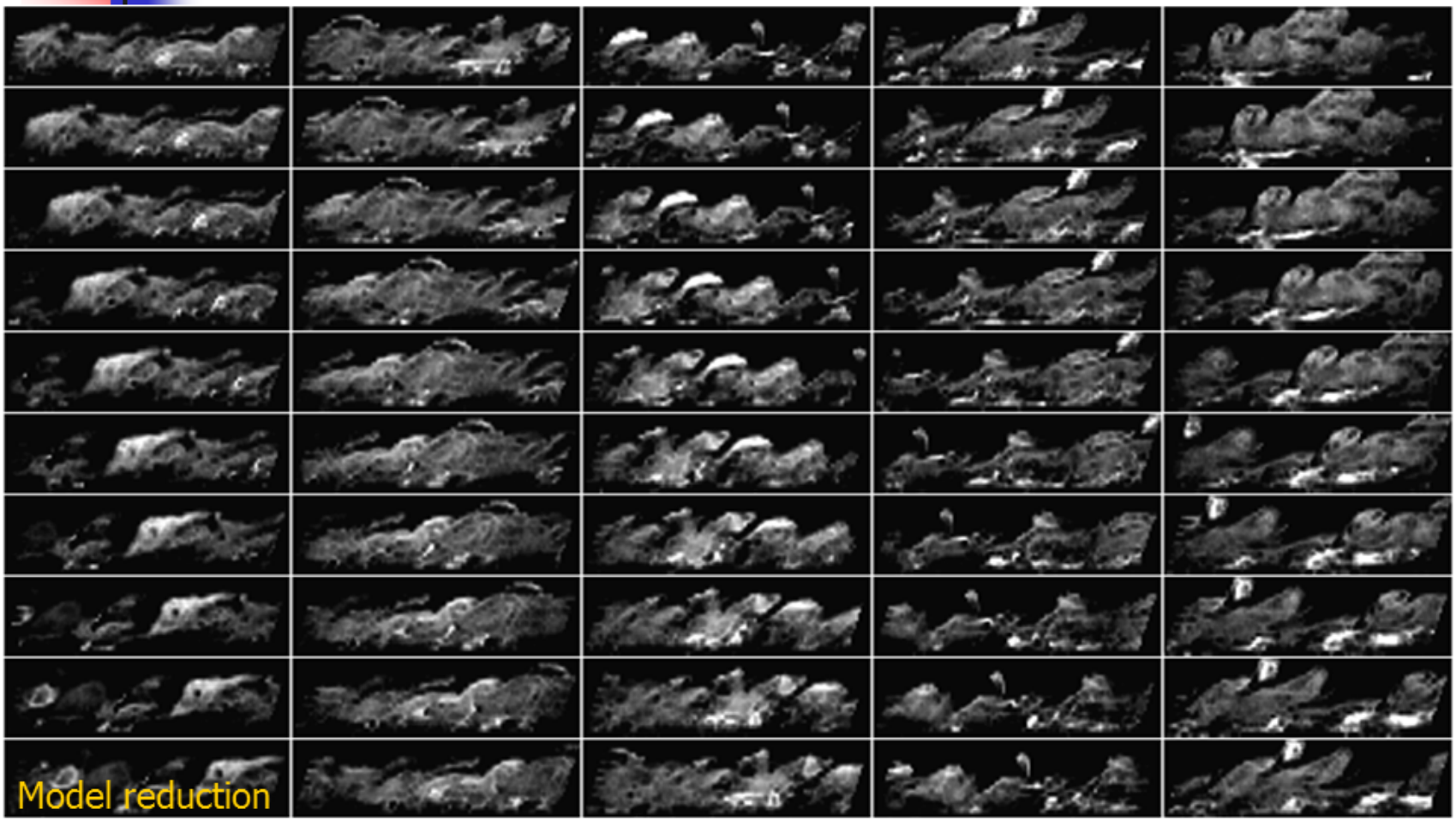


Two main grips in our struggle with complexity



Turbulence:
it is infinite variety, isn't it?

Let us find main components



Dimension of flow space

The upper boundary: dim<const×Re^3

where Re is the Reynolds number (Osborne Reynolds, 1883):

$$Re = \frac{\rho v_s L}{\mu}$$

v_s - mean fluid velocity,
L - characteristic length,
μ - dynamic fluid viscosity,
ρ - fluid density.

Typical values of Reynolds number
Blood flow in brain ~ 100
Blood flow in aorta ~ 1000
Onset of turbulent flow ~ 2300
Person swimming ~ 4000,000
Aircraft ~ 10,000,000

Find main components, project and enjoy

Genomic sequence
as a text in unknown language

tagggtcgcacgtggtgagctgatgctaggg

frequency dictionaries:

t a g g g t c g c a c g t g g t g a g c t g a t g c t a g g g	$N = 4=4^1$
ta gg gt cg ca cg tg gt ga gc tg at gc ta gg	$N = 16=4^2$
tag ggt cgc acg tgg tga gct gat gct agg	$N = 64=4^3$
tagg gtcg cacg tggt gagc tgat gcta gggt	$N=256=4^4$

Model reduction

From text to geometry

cgtggtgagctgatgctagggtcgcacgtggtgagctgatgctagggtcgacgtggtgagctgatgctagggtcgc

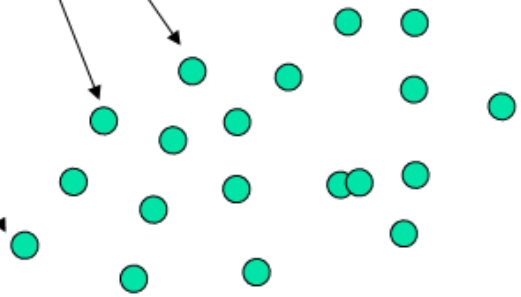
10^7

length~300-400

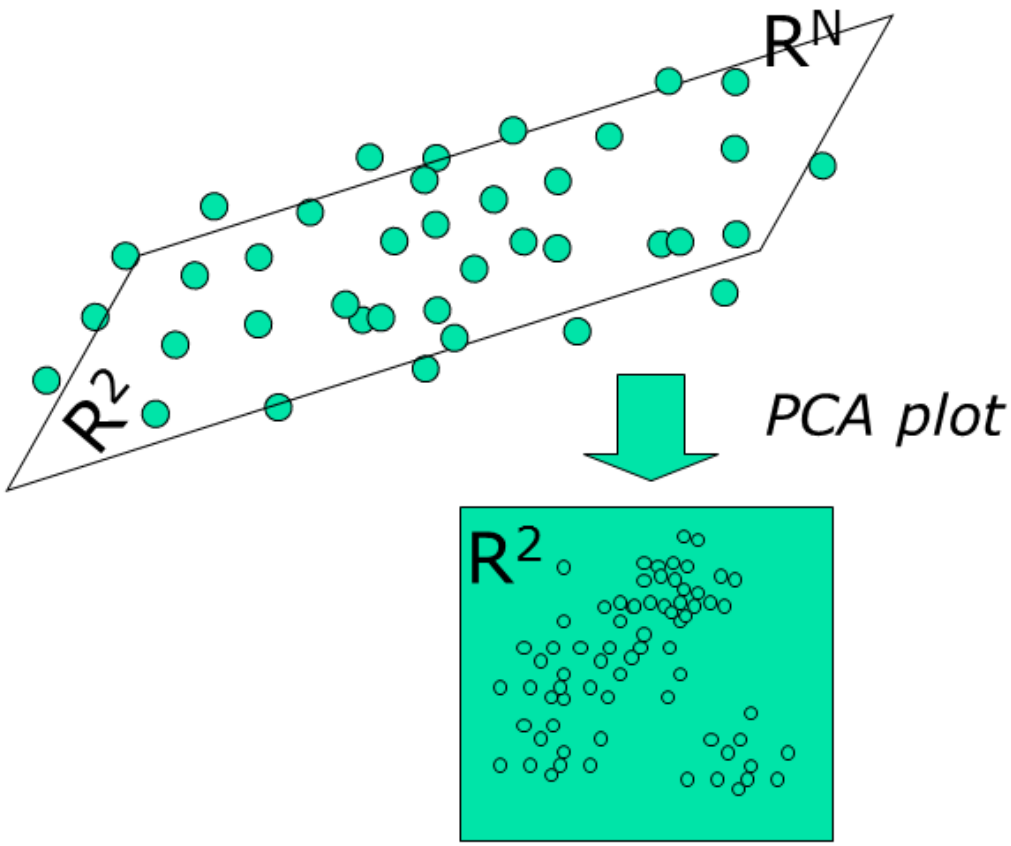
cgtggtgagctgatgctagggtcgcac
ggtgagctgatgctagggtcgcacact
tgagctgatgctagggtcgcacaattc
gtgagctgatgctagggtcgcacggtg
.....
gagctgatgctagggtcgcacaagtga

3000-4000 fragments

R^N



Method of visualization
principal components analysis



Caulobacter crescentus

singles
N=4

doublets
N=16

triplets
N=64

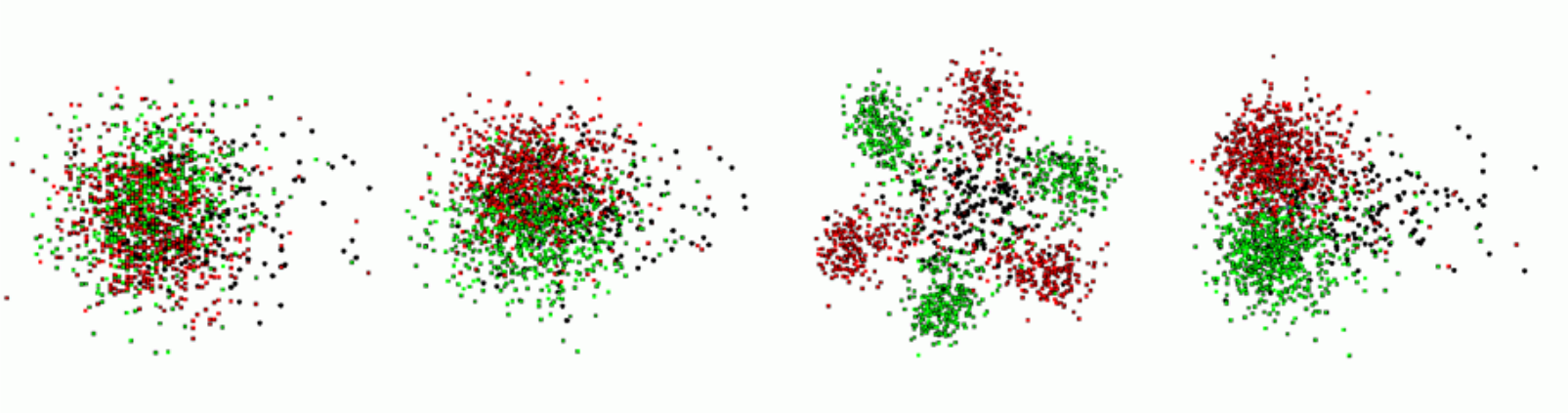
quadruplets
N=256

!!!

the information in genomic sequence is encoded by non-overlapping triplets

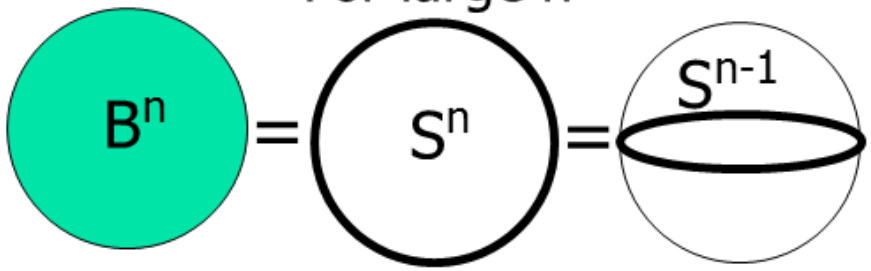
First explanation

cgtggtgagctgatgctagggtcgcacgtggtgagctgatgctagggtcgacgtggtgagctgatgctagggtcgc



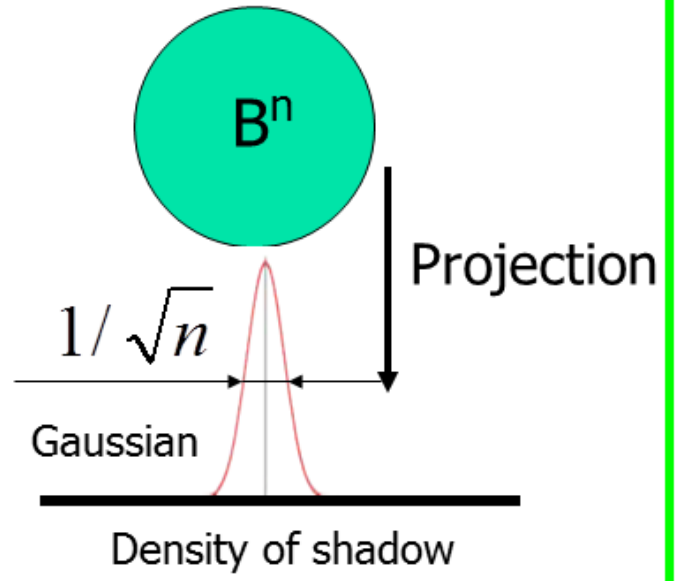
Measure concentration effects

For large n



Maxwell
Gibbs
Milman
Talgrand
Gromov
.....

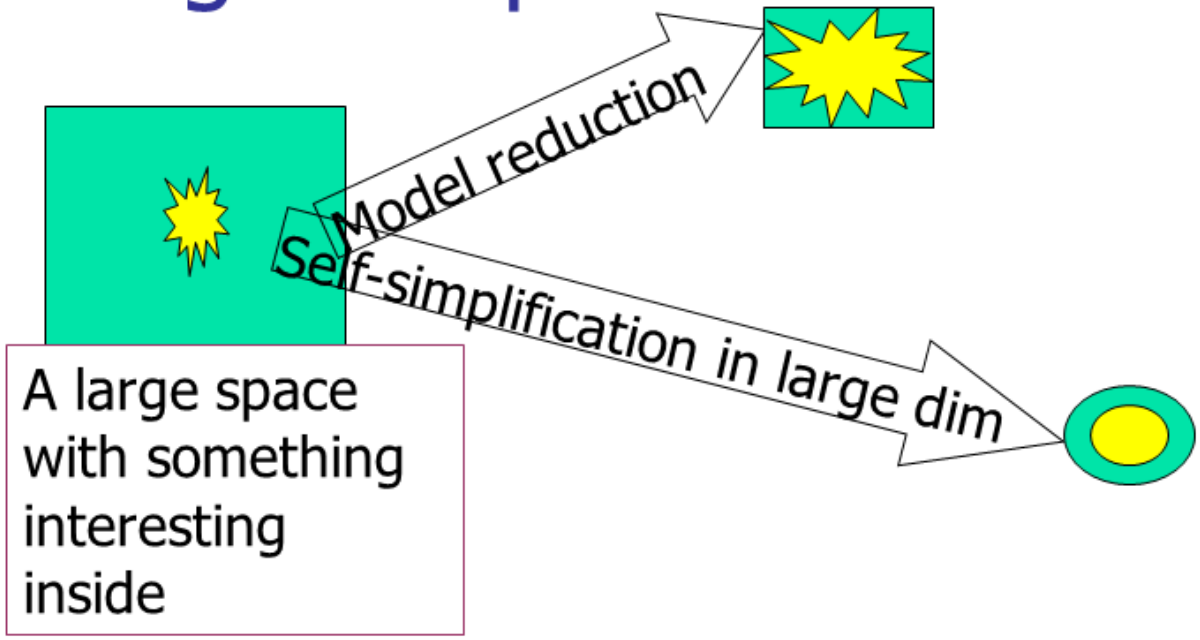
The Maxwell distribution



Self-simplification in large dim

Three provinces of the Complexity Land

Which way should we follow in a given specific case?



The future flexible technology should combine both

The stair of locomotive problems (1)

"Computational Turbulence": to compute turbulent flows with appropriate accuracy in appropriate time from the first principles.

"Chemical accuracy": the quantum chemistry calculations need at least a one more order in accuracy to predict the chemical features (energies) of molecules.

"Molecular individualism": how to describe dynamics of macromolecular complexes and media where different molecules have individual behavior and the averaging is impossible?

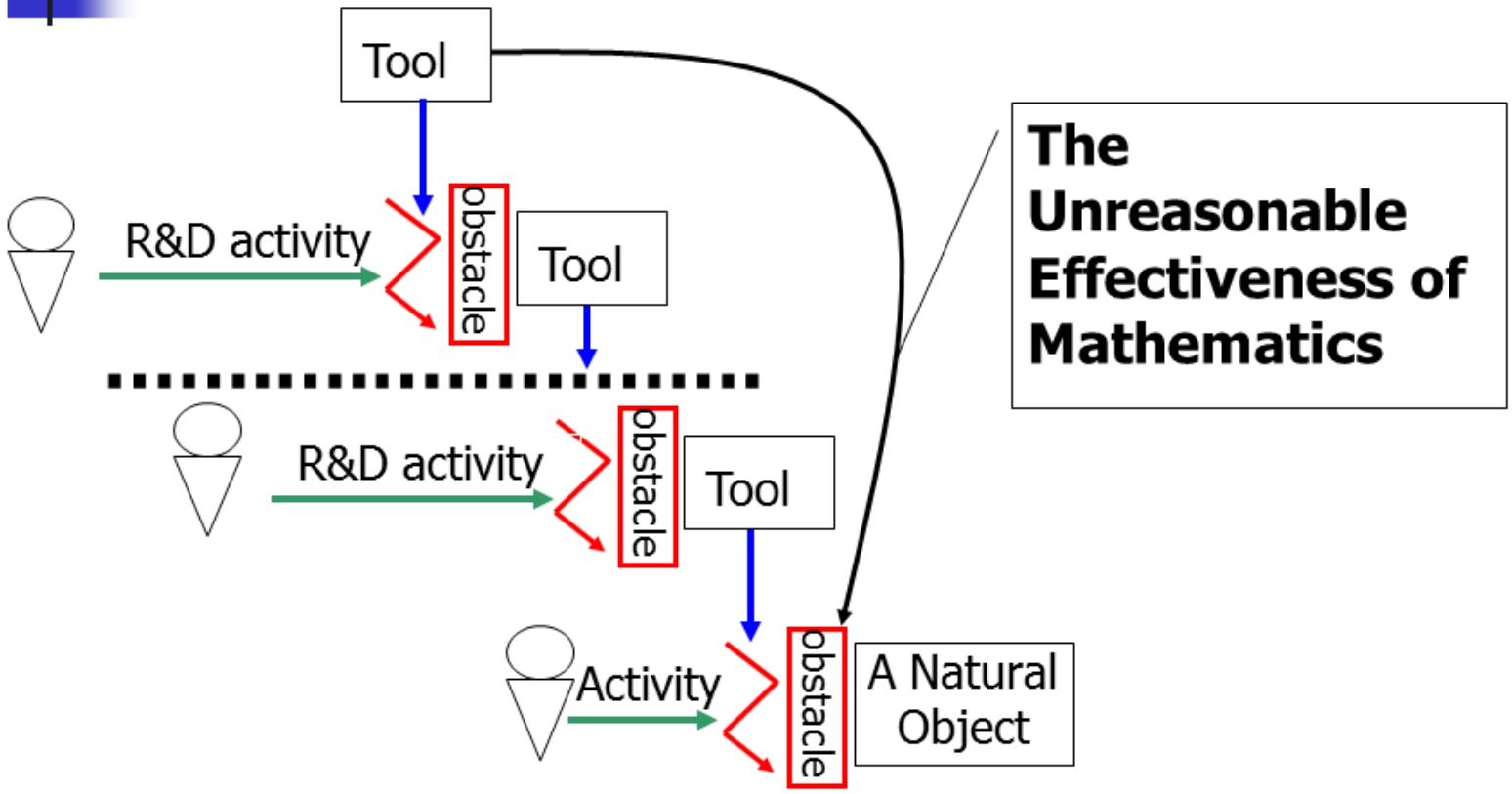
The stair of locomotive problems (2)

"Minimal Cell": to construct a mathematical computational cell model, based on the first principles, that will demonstrate the characteristic behavior of a cell.

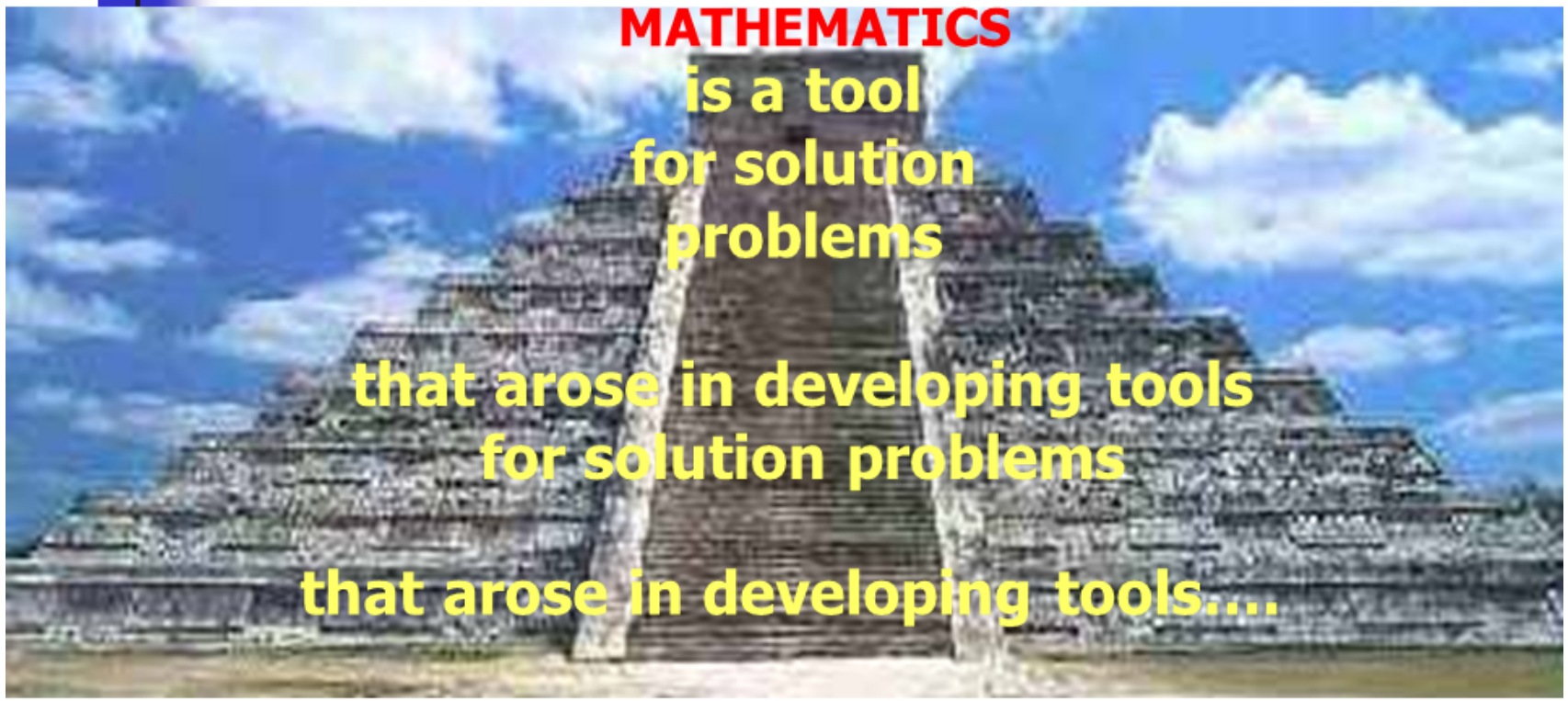
"Morphogenesis model": from cell to organism, computational modeling of embryological development of organism's structure.

"Artificial Brain": to construct a model of brain and living creature, that will demonstrate conscience and freedom of will.

The Unreasonable Effectiveness of Mathematics in the Natural Sciences

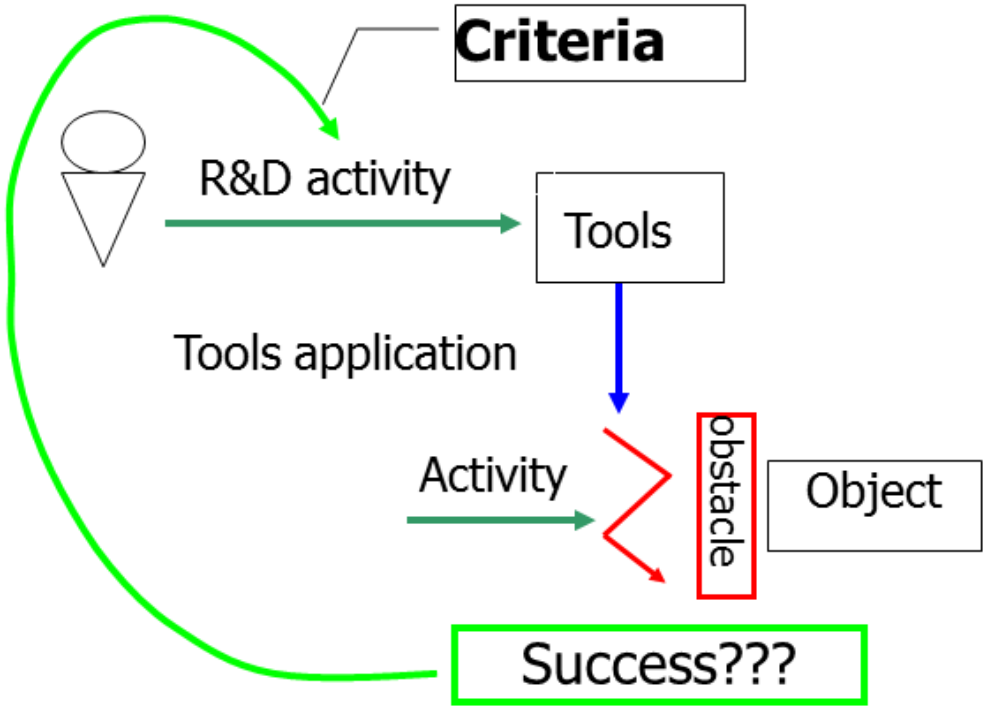


Mathematics develops as a gradual ascent on stairs of abstractions



It is not a miracle, that such a tool for tools, metatool or megatool can be effective downstairs.

The double vision of applied mathematics



And where is tomorrow's mainstream?

In the big ship of the past?

Or in the change of era?

And where is tomorrow's mainstream?

??????????

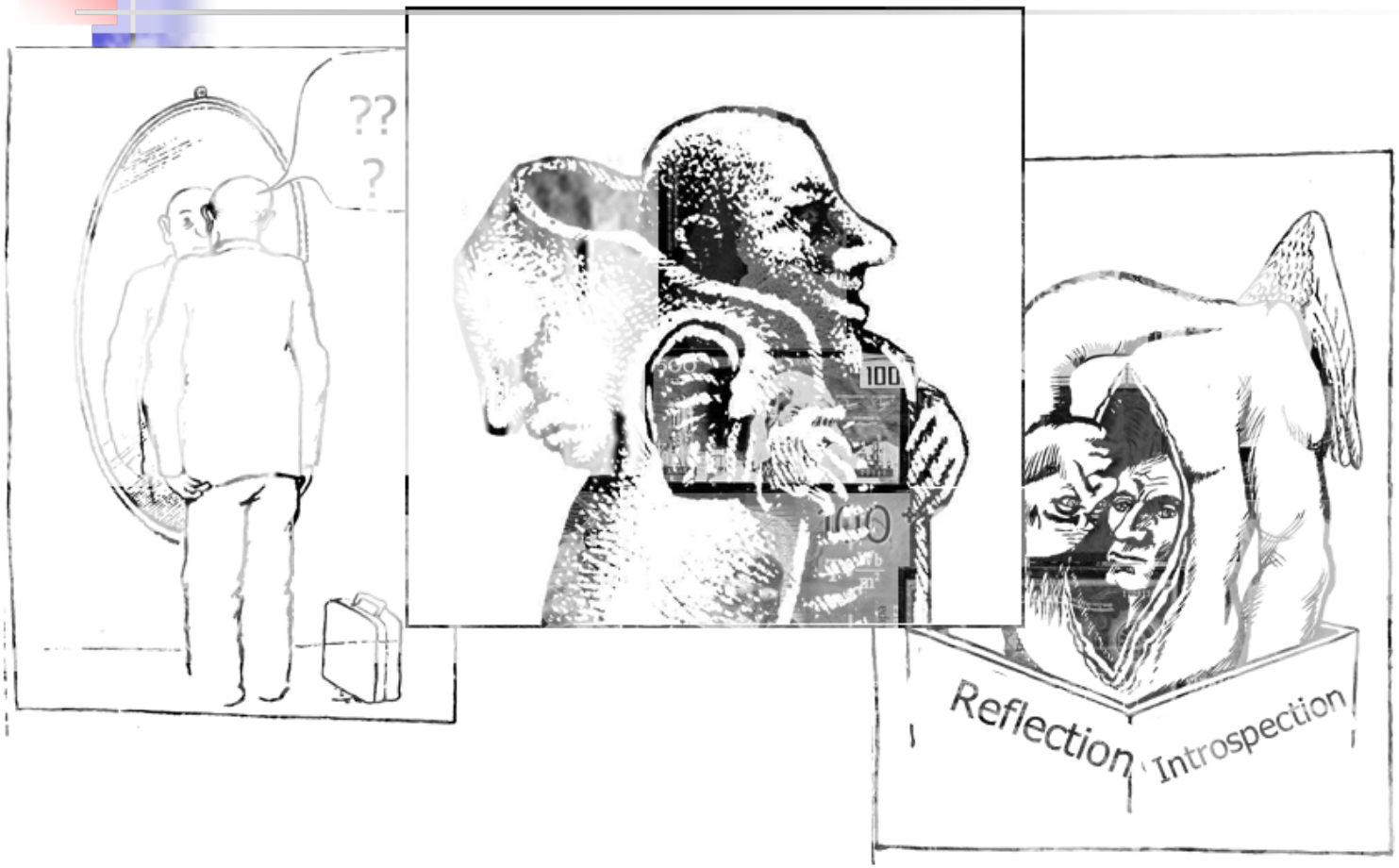
In the big ship of the past?

Or in the change of era?

Acknowledgments (1)

Acknowledgments (2)

Acknowledgments (3)



Acknowledgments

Thank YOU!