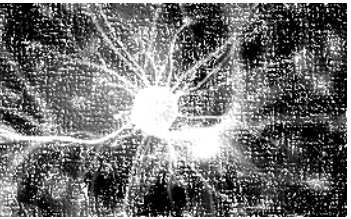

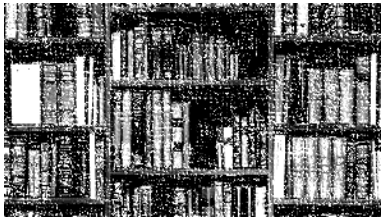

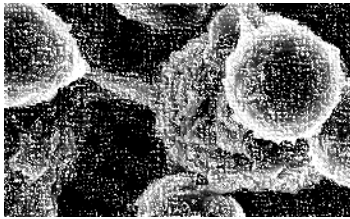

NATIONAL RESEARCH UNIVERSITY

# REFLECTIONS ON
## THE SCIENCE STUDIES

LITAU
EKATERINA

Doctor of Philosophy (Ph.D.) in Economics and Management,
Master of Science (M.S.) in Finance and Economics,
Juris Doctor (J.D.)

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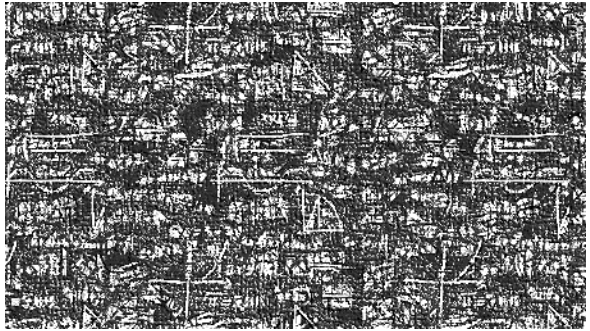
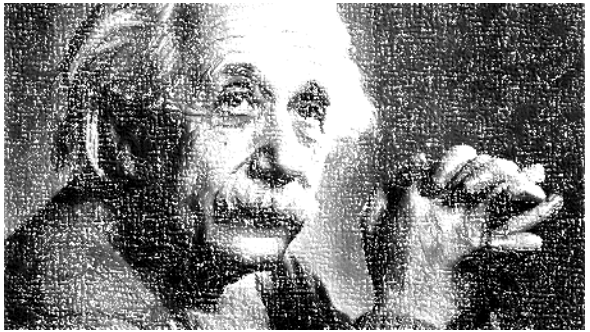
# The Origins of  the Science Studies (SciSt)



1960s

XX century

By the initiative of Soviet philosophers, the study of science *(the science studies)* was institutionalized as an interdisciplinary field studying the system of the main aspects of science functioning: its history, economics, psychology, management, and methodology



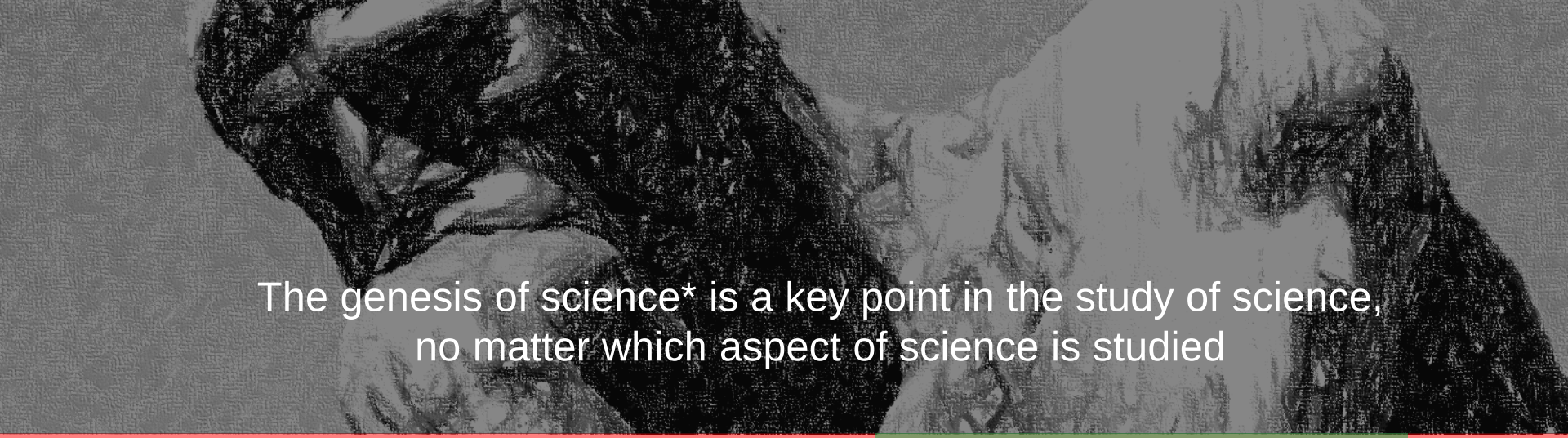
# The Origins of the SciSt

Before studying the science, it is important to decide which aspect of the science is of interest…

*Science can be studied as:*

- A system of knowledge
- Professionalized activity
- Social institution

The most complexly organized way of functioning of science is a social institution, which means the transformation of science into a popular occupation, which determines the speed and direction of social development.



# The genesis of science* is a key point in the study of science, no matter which aspect of science is studied

* Two competing theories on the origin of science exist in SciSt

## THEORY 1

Science emerged as a result of Socrates intellectual revolution at the turn of the 5th-4th centuries BC

## THEORY 2

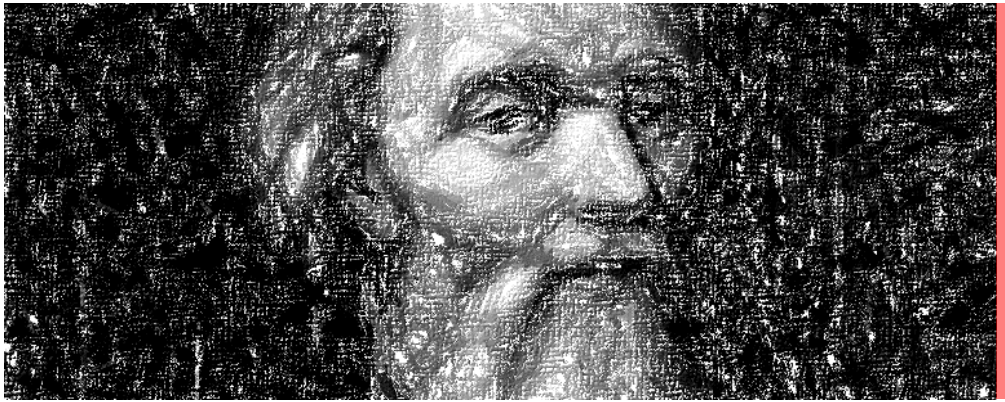
Science originated in the Modern Times *(16th-18th centuries)* when a first scientific view of the world was formulated – it was called a classical, mechanistic or Newtonian view of the world

# Indispensable attributes of the scientific knowledge

A scientific discovery can become operational only if it has a theoretical basis

Ivan Kulibin – a self-taught inventor - is a striking historical illustration of this principle

## Being theoretical is an indispensable attribute



When working on the construction site of one of St. Petersburg bridges, Kulibin actually discovered one of the laws related to the theory of the material resistance. However, having no university education, he could only formulate it in his own words, and hence, this discovery was not recognised as a scientific treasure.

The law did not work in science and was not applied in practice until an educated researcher of German origin discovered it anew, i.e. formulated and substantiated it theoretically.

# Indispensable attributes of the scientific knowledge

**Theory** is a system of categories, principles and laws. A scientist should, above all, be able to operate a system of scientific concepts and categories.

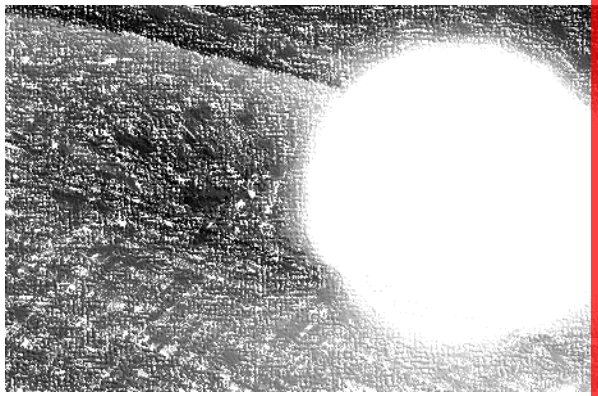
*How can a chemist work if he or she does not know relevant terminology?*

*A scientist can formulate initial principles of a scientific theory only by means of the system of relevant categories.*

**"Cultural symbol"** – Archimedes' exclamation 'Eureka!'

**Scientific principle** is a judgement taken as a self-evident truth, which serves the basis of a scientific theory; in other words, a scientific principle is not proved logically, but rather accepted as it is.

# The apple of Isaac Newton

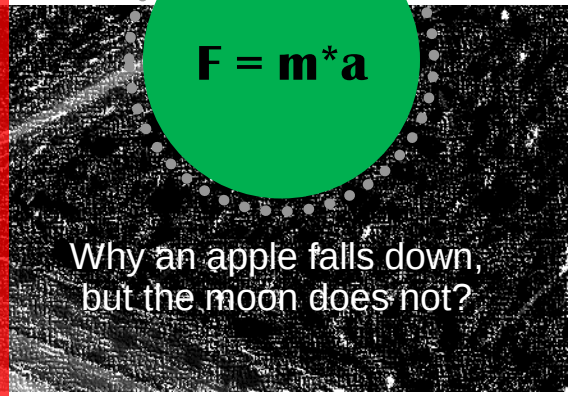


**The truth, which Newton saw as self-evident, had to be proved with theory**

Thus, the three laws of mechanics emerged comprising a classical theory of mechanics, the top of which is the Law of universal gravitation

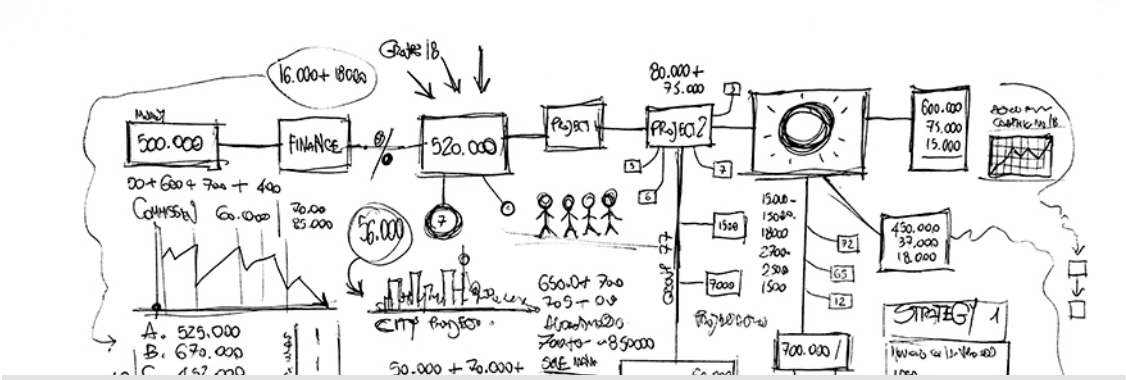
## Universal force of gravity

A scientific genius – Isaac Newton, was generous to share with public the very moment of the scientific discovery: in his memoirs he described the moment of eureka, when he was observing a falling apple




A law represents a connection between phenomena, but not any kind of connection: only internal, significant, objective, general, indispensable, and of a repeated effect.

# Indispensable attributes of the scientific knowledge




## Besides being theoretical, a scientific theory must be objective

Objectivity is a sufficient attribute of science

**Scientific objectivity** guarantees the expected result upon the application of theory, no matter which agent makes use of the theory, although special conditions implied by the theory are to be observed

*This aspect is especially relevant for economics*

# Subjective factor: social mentality

Social reforms, while being successfully introduced in one country, are not necessarily as successful when implemented in another one.

The reason is that social laws, unlike natural laws, are the result of human endeavour, thus, people act freely and, quite often, carelessly.

Therefore *(when applying social laws)* a subjective factor is to be considered, and the core of it is social mentality

**Objectivity** is the essence of any law

**A social law is** objective by content, but subjective by the form of its manifestation. This aspect *(the impact of the subjective factor) has not been properly studied yet.*

# *So,* what is the science?

A  system of theoretical and objective knowledge

# Arguments supporting the theory of science resulted from Socrates intellectual revolution

## Socrates acted as the ”midwife” of science

Socrates argued that like his mother, he is engaged in midwifery (in ancient Greek it is “maieutics”), assisting in the process of birth, although it is the truth, not a child, which is born.

## Socratic dialogues aimed at helping the interlocutor to give birth to truth

All “pre-Socratics” worked on the fundamental problem of the origin and structure of the cosmos. Socrates announced: ‘Philosophy has nothing to do with the problem of Origin and the structure of Cosmos; the philosophy should address precisely the man’.

## Socrates differentiated between the subject and method of philosophy and science

As a result, the science gemmated of philosophy, and the specific scientific knowledge started developing independently, although theoretical and methodological relationship between philosophy and science continued to evolve

# Mathematics – the queen of the sciences

Initially, specific scientific knowledge was formulated in the field of mathematics, which is considered to be the language of science

The first sign of the emergence of specific scientific knowledge after Socrates intellectual revolution was the system of geometric knowledge developed by Hippocrates of Chios at the beginning of the 4th century BC and based on the method of mathematical induction.

A second step in the development of the specific scientific knowledge was a theory of regular polyhedra of Theetetus.

Mathematics was introduced to astronomy in the 4th century BC, when Eudoxus developed the first geometric geocentric astronomical model *

Thus, a general scientific rule of mathematization started to operate: once mathematics enters a field of knowledge, it starts to direct it like by a compass and steer it towards a higher theoretical level and scientific maturity

* Not accidentally, the first 'genuinely scientific revolution' occurred in astronomy, when in 16th century geocentric model was superseded by heliocentric model developed by Copernicus.

# Consequences of mathematization

*Emergence of theoretically mature social-humanitarian knowledge (which happened 150 years later than in natural sciences) is also the result of mathematization*

*Economics, due to the peculiarity of its subject, plays a special role in the process of mathematization, adapting the mathematical methods for the usage in social sciences while considering the rich tradition of mathematical methods in natural sciences*

## Leonid Kantorovich

At some point, research efforts of Russian scientists turned into triumph: in 1975, Leonid Kantorovich was awarded a Nobel Prize for the **development of mathematical methods in economics**.

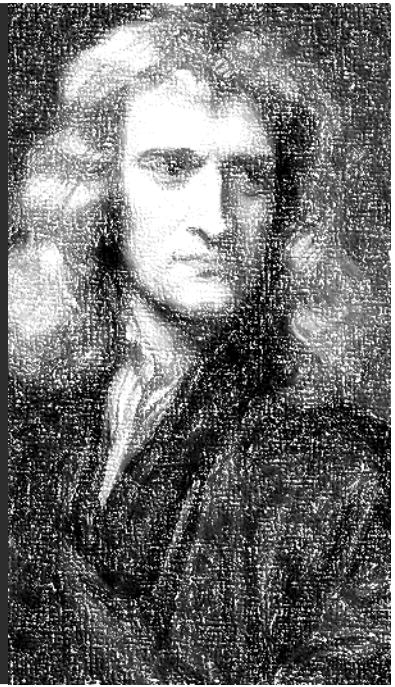
# Theory 2 of the genesis of science

## Newton *

As the author of the first scientific worldview

## 17th century

**Scientific worldview is a theoretical representation of the world in general, formulated by professional academic community by means of the system of categories, principles and laws**



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*Development of the first scientific worldview indicates that the science, in general, is getting more theoretically matured*

# Resolving the problem of the genesis of science

Danilevsky N.Y. *(second half of the 19th century)* – the author of ‘Russia and Europe’’

The two theories of the science genesis are considered competing, although in fact they are not. Russian thinker **Danilevsky N.Y.** proved it by suggesting a solution of the problem of the genesis of science.

Criterion defining the birth of science is a conscious understanding of the subject and appropriate method of research in a specific area of knowledge

While considering the development of science within the history of culture, Danilevsky writes that emergence of science should not be associated with the level of its maturity, the science is all areas of scientific knowledge - just as a human is any kind of man, no matter a child or an adult.

It would be logical to admit, that science starts to develop as a system of specific scientific knowledge resulted from Socrates intellectual revolution, when the subject and method of science were differentiated from the subject and method of philosophy. The evolution of the system of specific scientific knowledge in Antiquity, the Middle Ages and Renaissance led to the establishment of science as an profession in the Modern Times, when the science became a type of spiritual production, as interpreted by Marx.

# Formation of science as a social institution

**19th-20th**
centuries

At the turn of the 19th -20th century, the science starts to shape as a social institution

**Friedrich Engels:**
the most significant discoveries should be expected at the intersection of sciences

Turning into a popular occupation and embracing all areas of empirically observed world in the research process, the science starts to determine direction and speed of the social development

By this time, natural sciences achieve a very high level of development; social and technological knowledge get established as specific scientific branches of knowledge

Due to the emergence of these three branches of scientific knowledge, which cover the entire natural reality, the scientific community comes to the conclusion that the world is unite, and it would be more effective to study any phenomenon of this world using an interdisciplinary approach

An striking example is scientific and pedagogical activities of Vernadsky V.I., who started as a geologist, and after a couple of decades became known as a biochemist

# Interdisciplinarity

# Scientific paradigm

Science's becoming a paradigmatic force

Paradigm as a scientific category was introduced by **Thomas Kuhn** *('The Structure of Scientific Revolutions')*. He used this term to define a scientific revolution. According to Kuhn, the essence of the scientific revolution is the shift of a scientific paradigm

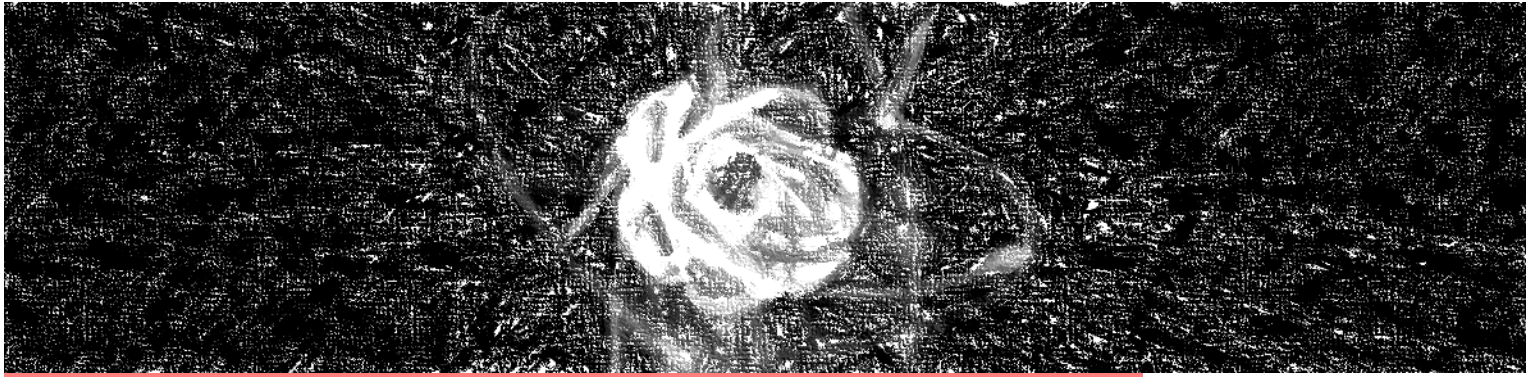
The outcome of the scientific revolution *(according to Kuhn)* is the shift of a scientific paradigm

**Scientific paradigm is** an optimal algorithm developed by professional scientific community to describe the activity of a social agent under specific historical conditions

Mechanistic paradigm is being elaborated *(16th-18th centuries)*

Mechanistic paradigm refers not only to natural processes, but also to society and a human. In other words, **both society and a human** are viewed as a **kind of a mechanism** *(Lamettrie, 'l'Homme Machine')*

# A transition moment in the history of science



The mechanistic paradigm corresponded to the stage of the classical science in the Modern Times, in the 16th-17th centuries

The 19th century became a transition period in the history of science: it was the time of developing revolutionary theories *(in geology, biology) and making scientific breakthroughs* in various areas of knowledge

*The key point of this scientific process is the discovery of electron, i.e. the divisibility of the atom*

# Relativistic paradigm

At the turn of the 19th and 20th centuries, as a result of the scientific revolution, the mechanistic paradigm was replaced by the relativistic paradigm developed under the framework of Einstein’s worldview

The essence of this non-classical paradigm is that everything is relative. Relative to what? The starting point of the analysis is the subject, and certain scientific models and technologies are built in relation to his specific goals and interests.

# Global evolutionism

At the turn of the 1960s-1970s, another shift of scientific paradigm occurs: there starts the development of a new post-non-classical scientific worldview of global evolutionism. By this time, interdisciplinarity in science reaches maturity, which is manifested in the emergence of cybernetics as an interdisciplinary area.

Cybernetics is an interdisciplinary area that develops a mathematical theory of informational functioning of complex dynamic systems of any nature based on the feedback principle

# Cybernetics as an interdisciplinary area

In natural, in social and in technological systems there exist common laws of functioning

Mathematical theory of cybernetics gives rise to modern IT: from Electronic Calculating Machine to PC

## Norbert Wiener – a father of cybernetics

In his books 'I am a Mathematician' and 'Cybernetics', published in Russian, Wiener explains the genesis and mathematical theory of information processes of any nature

# Authors of classical and non-classical scientific worldview

- Classical and non-classical scientific worldviews have their authors: Newton and **Einstein**, who admitted that their scientific achievements resulted from a collective efforts

| | |
|---|---|
| **Newton** said, "if I have seen farther than others, it is because I was standing on the shoulders of giants" | **Einstein used** has put it more grotesquely: “Genius is a dwarf standing on the shoulders of giants, his predecessors’ |

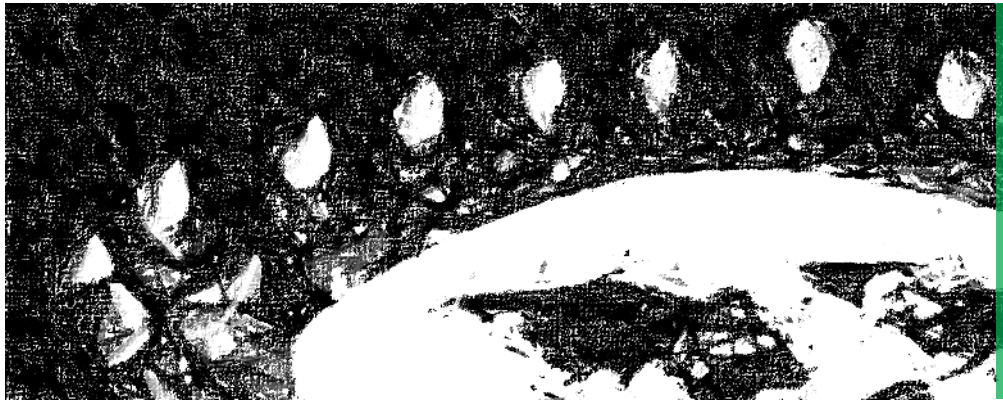
*Post-non-classical worldview (unlike classical and non-classical) has no embodied author, because by that time the popularity of the scientific occupation and interdisciplinary approach have already matured.*

# The Club of Rome – solution of the environmental problem

At the turn of the 1960s-1970s, some scientific groups work effectively within the Club of Rome

**Peccei** saw a threat in increasing technological human activity

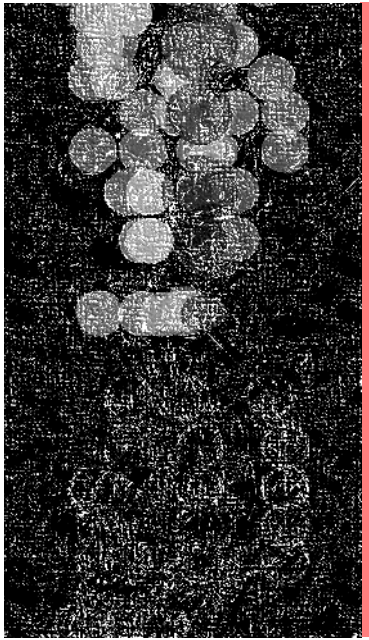
## A. Peccei is the initiator of the Club of Rome



Upon request of the Club of Rome, scientific groups developed a methodology for solving an environmental problem (technologies of closed industrial cycles, waste-free production, etc.). The key methodological achievements of the Club of Rome include development of global computer modelling of natural and social processes.

The collective work of the scientific groups of the Club of Rome prepared the transition to post-non-classical science, contributing to the emergence of the worldview of global evolutionism

# Principle of coevolution – the essence of global evolutionism paradigm



## The essence of the global evolutionism paradigm is the principle of coevolution

This paradigm is based on a specific problem-solving methodology, relying on the analysis of dynamics of society and nature as one organism

- Evolution of culture and evolution of nature is one process
- Further progress is impossible without an interdisciplinary approach
- The underlying meaning of the principle of coevolution is biophilia

***Biophilia*** *is understanding of the value of all forms of life*