BETWEEN MATTER AND SPIRIT – SOME PHILOSOPHY

Interdisciplinary seminar at the postgraduate studies in the Aleksander Krupkowski Institute of Metallurgy and Materials Science, Polish Academy of Sciences, conducted by prof. Eugeniusz Szumakowicz with participants:

Piotr Bobrowski, Marta Gajewska, Honorata Kazimierczak, Grażyna Kulesza, Jagoda Poplewska, Katarzyna Stan-Głowińska, Agnieszka Jelonek and Jakub Cichoszewski

Outline:

1. *Introduction* – **Prof. Eugeniusz Szumakowicz**
2. *Intellectual and research personality of Dmitri Mendeleev* – **Honorata Kazimierczak**
3. *Early views on the structure of matter - Empedocles and Anaxagoras* – **Katarzyna Stan-Głowińska**
4. *Atomic theory according to Democritus, Epicurus and Lucretius* – **Marta Gajewska**
5. *Bronze Age, Iron Age – from the history of material culture* – **Agnieszka Jelonek**
6. *Alchemy* – **Piotr Bobrowski**
7. *Between Chemistry and Physics* – **Grażyna Kulesza and Jagoda Poplewska**
8. *Summary* – **Prof. Eugeniusz Szumakowicz**

Introduction

The name of Socrates is a symbol of philosophical attitude. Socrates used to say: „Know thyself!". Thereby he stressed the role of the human factor in thinking and acting. But the great philosopher had also a respect for natural research. He appreciated his contemporary (5 century b. Ch.) natural scientists such as Anaxagoras or Empedocles. The idea of this seminar is to expound the historical, genetic and evolutionary perspective which could stimulate nowadays reasearch of young material sciences postgraduate students.

At the very begining of the philosophical and scientific cognition was the so called *problem of arché*. It may be formulated as an interrogation: *What is the primordial principle, basis or so called Grund, Grundlagen (germ.) of nature and/or whatsoever being ?*

Tales from Miletus and Pythagoras from Samos were the first who gave their specific answer to this fundamental question. Pythagorean answer was more mathematical and later on was continued by Plato's school and the succesors of this father of ancient greek classical philosophy. Interestingly thislike stream of thinking was taken up by many XX century theorethical physicists who used to say and stress that the nature is mathematical. On the other hand, not the whole nature is mathematical, but only a small part or aspect of it. Experimental physicists and material scientists know it very well. So we center our attention in this compendium on physico-chemical part of natural sciences and its interrelation with engineering and technology.

That is why not Albert Einstein, but Dimitry Mendeleyev is the main intellectual hero of the presented essays. Contemporary philosophers of science usually combine philosophy with physics or with biology, not with chemistry. We try below to change this situation and constellation, and we are making an attempt to build some beginnings of a philosophy of chemistry.

Looking for origins draws us back to ancient Greek Democritus and Empedocles. The latter may be named an ancient Mendeleyev. This is shown in the chapter devoted to Empedocles and Anaxagoras. The saying of an emitent historia of science E.T. Bell: „modern minds in ancient bodies" seems to be fully justified.

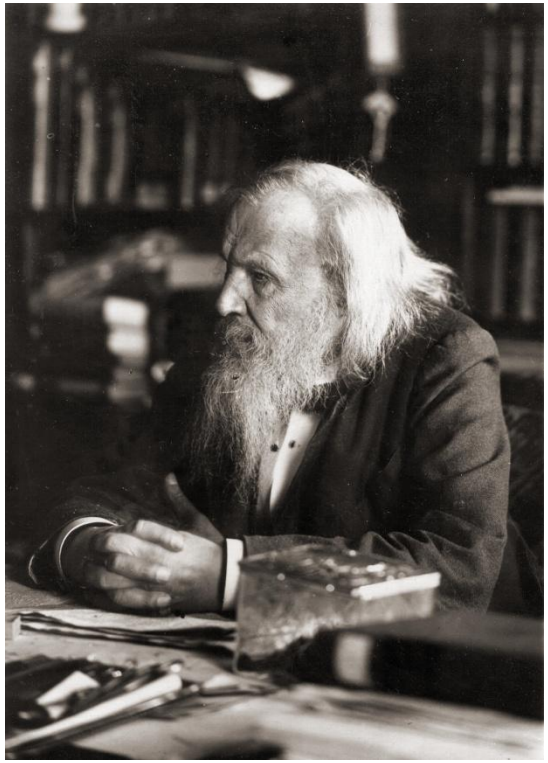
The objective of the last by one chapter is to expose the complex and difficult problem of mutual relation between physics and chemistry. Epistemological ad methodological autonomy of chemistry is at stake.

The last part is a symbolic exposition of one more interrelation, of an extraordinary importance and significance. It has a transcendental charakter. One means the relation and conditionning between human subject and the objective world. The main and final conclusion is as follows: *the man is not a part of the world or nature, but a limit of it* .

Prof. Eugeniusz Szumakowicz

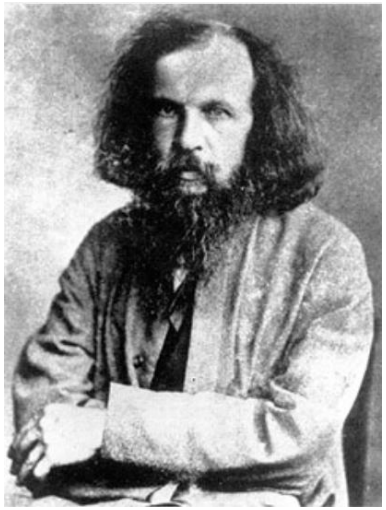
Honorata Kazimierczak

Intellectual and research personality of Dmitri Mendeleev



http://upload.wikimedia.org/wikipedia/commons/c/c8/DIMendeleevCab.jpg [dostęp 2013-11-15].

Dmitri Ivanovich Mendeleev, **Дмитрий Иванович Менделеев**



http://www.nndb.com/people/593/000091320/ [dostęp 2013-11-15].

Born 8 february 1834 in Tobolsk,
Died 2 lutego 1907 in Petersburg

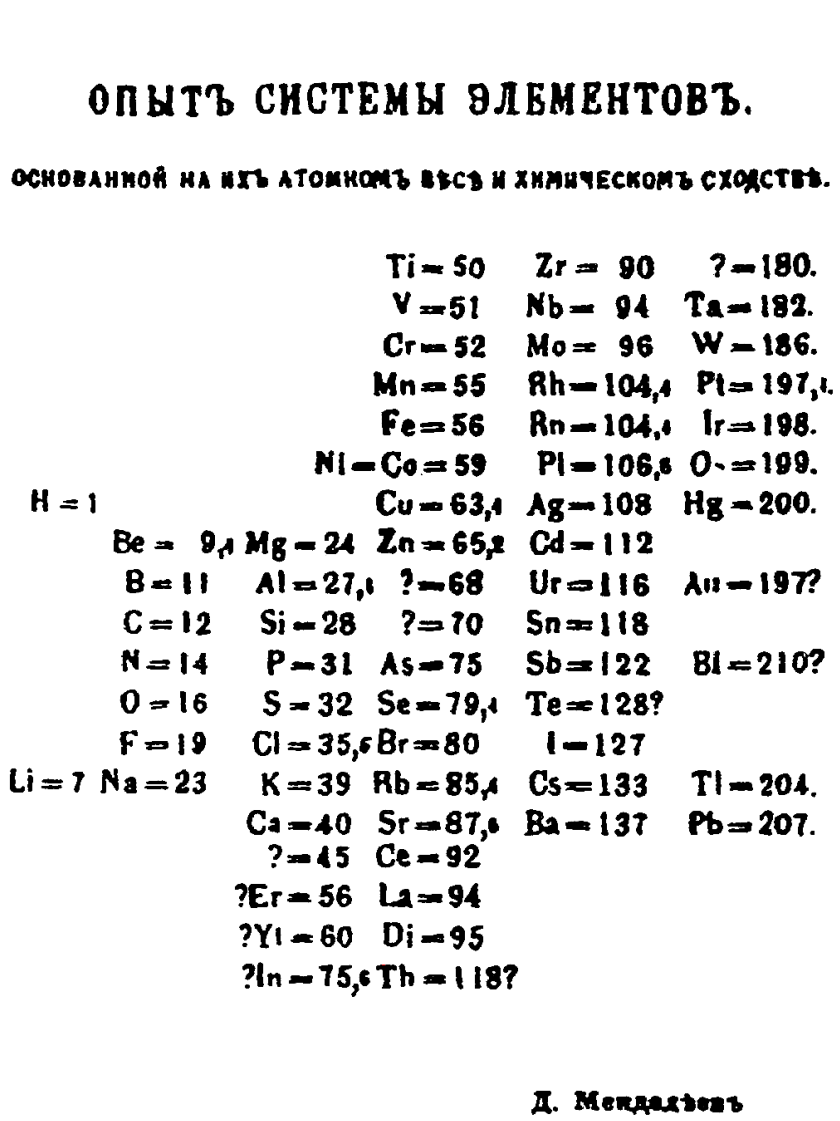
Russian chemist and inventor;

since 1864 professor of technical and inorganic chemistry at Saint Petersburg State Institute of Technology
1865-1890 – professor of Saint Petersburg State University,
since 1892 head of Central Office of Measures in Russia;
since 1876 corresponding member of the St. Petersburg Academy of Sciences,

The active member of many foreign academies of sciences, among others Polish Academy of Learning (1891)

He contributed to the establishment of the Russian Chemical Society.

[1,2]



ОПЫТЪ СИСТЕМЫ ЭЛЕМЕНТОВЪ.

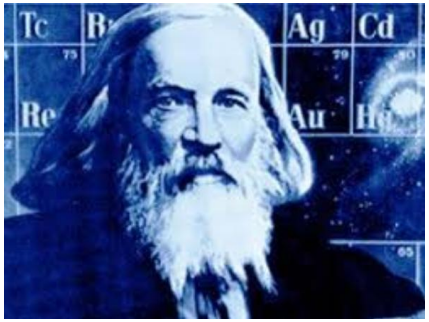
ОСНОВАННОЙ НА ИХЪ АТОМНОМЪ ВѢСѢ И ХИМИЧЕСКОМЪ СХОДСТВѢ.

			Ti = 50	Zr = 90	? = 180.	
			V = 51	Nb = 94	Ta = 182.	
			Cr = 52	Mo = 96	W = 186.	
			Mn = 55	Rh = 104,4	Pt = 197,1.	
			Fe = 56	Ru = 104,4	Ir = 198.	
			Ni = Co = 59	Pl = 106,6	O = 199.	
H = 1			Cu = 63,4	Ag = 108	Hg = 200.	
	Be = 9,4	Mg = 24	Zn = 65,2	Cd = 112		
	B = 11	Al = 27,4	? = 68	Ur = 116	Au = 197?	
	C = 12	Si = 28	? = 70	Sn = 118		
	N = 14	P = 31	As = 75	Sb = 122	Bi = 210?	
	O = 16	S = 32	Se = 79,4	Te = 128?		
	F = 19	Cl = 35,6	Br = 80	I = 127		
Li = 7	Na = 23	K = 39	Rb = 85,4	Cs = 133	Tl = 204.	
		Ca = 40	Sr = 87,6	Ba = 137	Pb = 207.	
		? = 45	Ce = 92			
		?Er = 56	La = 94			
		?Yt = 60	Di = 95			
		?In = 75,6	Th = 118?			

Д. Менделѣевъ

http://upload.wikimedia.org/wikipedia/commons/b/bb/Mendeleev%27s_1869_periodic_table.png [dostęp 2013-11-15].

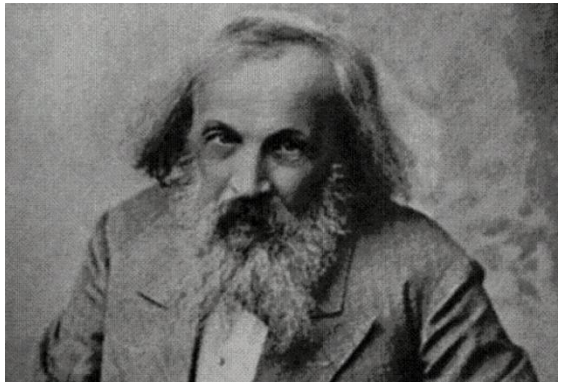
Table of the elements published in 1869



D.I. Mendeleev published in 1869. the first periodic table.

Mendeleyev's breakthrough idea was to leave blank spaces where there were large differences between the atomic weights of the elements known at that time and also the regularity of their chemical properties was disrupted.

Mendeleev predicted the existence of eight elements, three of which were discovered in his lifetime (germanium, [3] gallium and scandium).



It is generally little known fact, the discoverer of the law of periodicity of the chemical elements left a lasting impression not only in the field of theoretical and applied chemistry, but also in mathematics, metrology, physics, meteorology, aeronautics, ballistics, agronomy etc.

Over the last fifteen years of his life the scientist headed the Central Office of Weights and Measures in Russia.

Mendeleev's writing legacy includes 25 volumes of works, from which up to one-third is devoted to such humanistic issues as:

pedagogy, sociology, aesthetics, economics and law.

D.I.Mendelejew (1882)

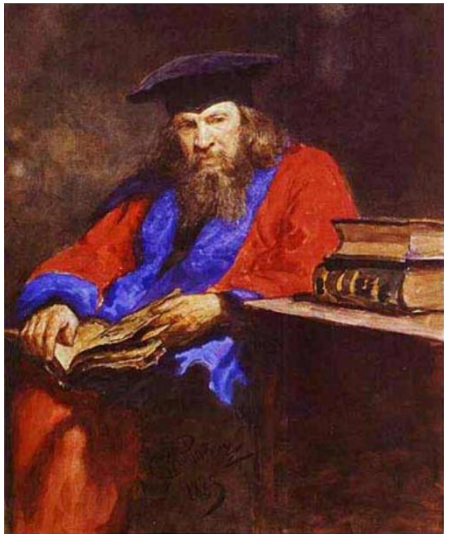
http://www.purand.pl/pur1/mendel.htm

[4,5]

The philosophy of Mendeleev

The philosophy had a very significant place in the work of Mendeleev.

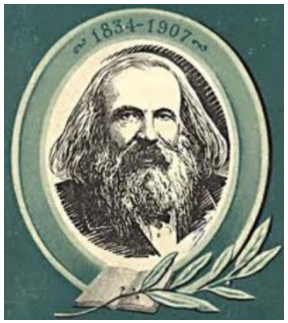
According to biographical information, the scientist had a negative attitude to the classic metaphysical systems, criticizing them for speculative nature, devoid of empirical base [4,6]



http://vivovoco.rsl.ru/VV/JOURNAL/NATURE/02_07/DIM.HTM

The philosophy of Mendeleev [4]

Although the verbal declarations against classical metaphysics, Mendeleev accept the value of philosophy.

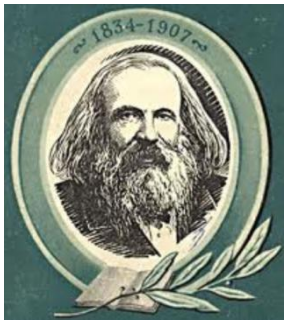


Mendeleev also count the natural sciences among o the philosophical disciplines in the broad sense.

„the main object of the work are philosophical principles of our science referring only to its basic or elementary, qualitative and quantitative information about the chemical elements "

D. I. Mendelejew, Osnowy chimii. [7]

The philosophy of Mendeleev [4]



According to Mendeleev the root of reality is the triad of:

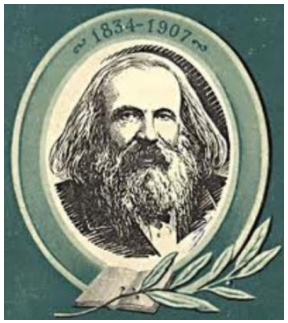
matter

energy

spirit

Science should investigate their manifestations,
in which they occur together.

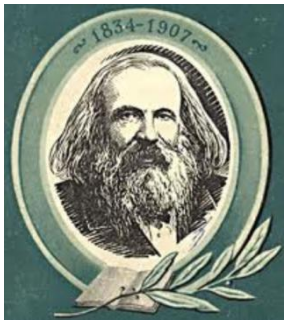
The philosophy of Mendeleev [7]



Mendeleev himself described his philosophical position as "realism", in contrast to the extreme idealism on one side and radical materialism on the other.

In his opinion, science should maintain permanent contact with reality rather than resort to supernatural explanations.

The philosophy of Mendeleev [4]



According to Mendeleev , taking into account, both empirical and theoretical elements in the study allows to avoid ruinous three attitudes:

1) aspirations of idealism to learn about the world on the basis just on speculation,

2) skepticism, contradicting any scientific data,

3) radical empiricism, based on the results achieved without awareness of their limitations.

Philosophical remarks about science [4] [8]

The objectives of the of science according to Mendeleev :

1) Expanding of the horizons of human knowledge

Scientific knowledge is not satisfied with the description of the phenomena, but aims to explain their reasons.

2) Bringing practical advantages, namely the use of the achievements of science in the development of techniques and technologies

The scientist initiated the creation of the oil industry in the Black Sea region, and called for the modernization of agriculture. For many years he edited the Encyclopedia of the Technology, which published valuable monographs in various fields of industry.

Stages of scientific cognition [4]

Mendeleev attributed the most important role in the scientific study to formulation of hypothesis - daring supposition, which allows to determine the internal relationship between the studied phenomena.

Scientific research by Mendeleev proceeds as follows:

1) Formulation of the hypothesis

2) Testing a hypothesis using the experiments

3) The creation of the theory, which allows you to locate the object cognized in the broad context of knowledge

As Mendeleev wrote: ***„building of science needs not only the material, but the plan”*** [10]

The limits of of science [4]

According to Mendeleev, no theory is final.
Science by its nature does not recognize the "essence" of things, does not reveal any "absolute" truth, but only constantly seeks er.

Mendeleev wrote that service of science teaches both modesty and perseverance. Caution in declaring "the last word of science" must be combined with courage in striving the path exploration.

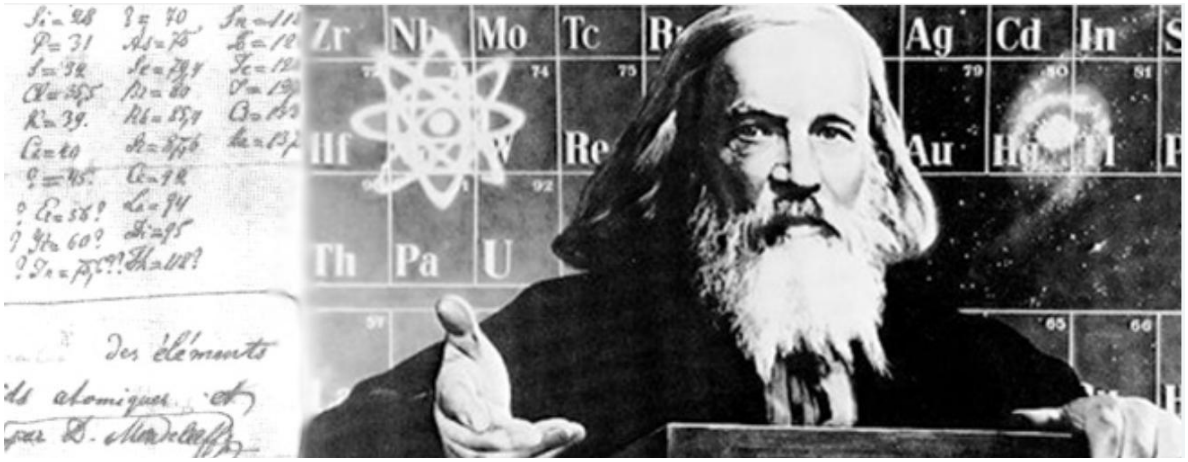
The scientist did not deny the existence of objective truth, although unknowable by us fully.

Summary

Mendeleev had a deep sense, the study is in a constant development, therefore he regarded many of his own concepts as more or less confirmed hypothesis.

Postulate of Mendeleev advising to combine openness towards new theories with caution, is up to date.

[4]



[11]

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[2] http://portalwiedzy.onet.pl/48773,,,,mendelejew_dmitrij_i,haslo.html [dostęp 2013-11-15].

[3] http://www.polskieradio.pl/7/179/Artykul/380499,Tajemnice-tablicy-Mendelejewa [dostęp 2013-11-15].

[4] D.I. Mendelejewa filozofia nauki, Semina Scientiarum, 4, 2005, 2.49

[5] *Istorija russkoj fiłosofii, M. A. Masłow i in. (red.), Riespublika,* Moskwa 2001, s. 366.

[6]P. Strathern, *Mendeleyev's Dream. The Quest for the Elements,*Penguin Books, London 2001, ss. 263, 277.

[7] D. I. Mendelejew, *Osnowy chimii. Priedisłowije k 8–mu izdaniju w: (red.)* B. W. Jemieljanow, *Russkaja fiłosofija wtoroj połowiny XIX wieka. Chriestomatija,* cz. I, Izd. Uralskogo uniwiersitieta, Swierdłowsk, 1991, s. 227.

[8] P. Biełow, dz. cyt., s. 223.

[10] D. I. Mendelejew, *Osnowy chimii. Priedisłowije. . . w: Russkaja fiłosofija.*. . , dz. cyt., s. 229

[11] http://persons-journal.com/journal/409/410 [dostęp 2013-11-15].

[12] http://pl.wikipedia.org/wiki/Dmitrij_Mendelejew [dostęp 2013-11-15].

[13] http://www.polskieradio.pl/39/246/Artykul/186933,O-polaczeniu-spirytusu-z-woda [dostęp 2013-11-15].

[14] http://abc-24.info/great_people_of_planet/681-dmitriy-ivanovich-mendeleev.html [dostęp 2013-11-15].

Early views on the structure of matter – - Empedocles and Anaxagoras

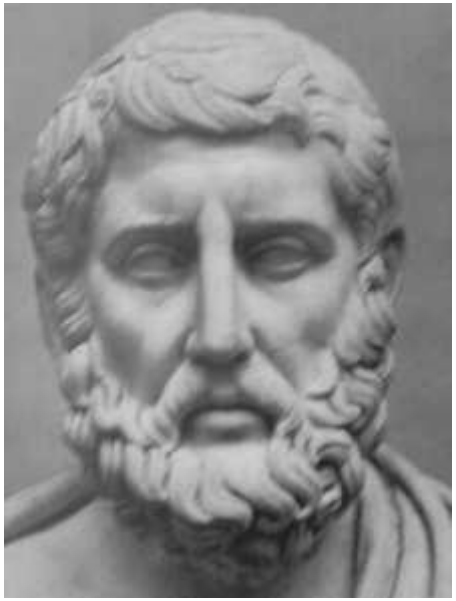
Anaxagoras
(Ἀναξαγόρας)

Empedocles
(Ἐμπεδοκλῆς)

Antecessors

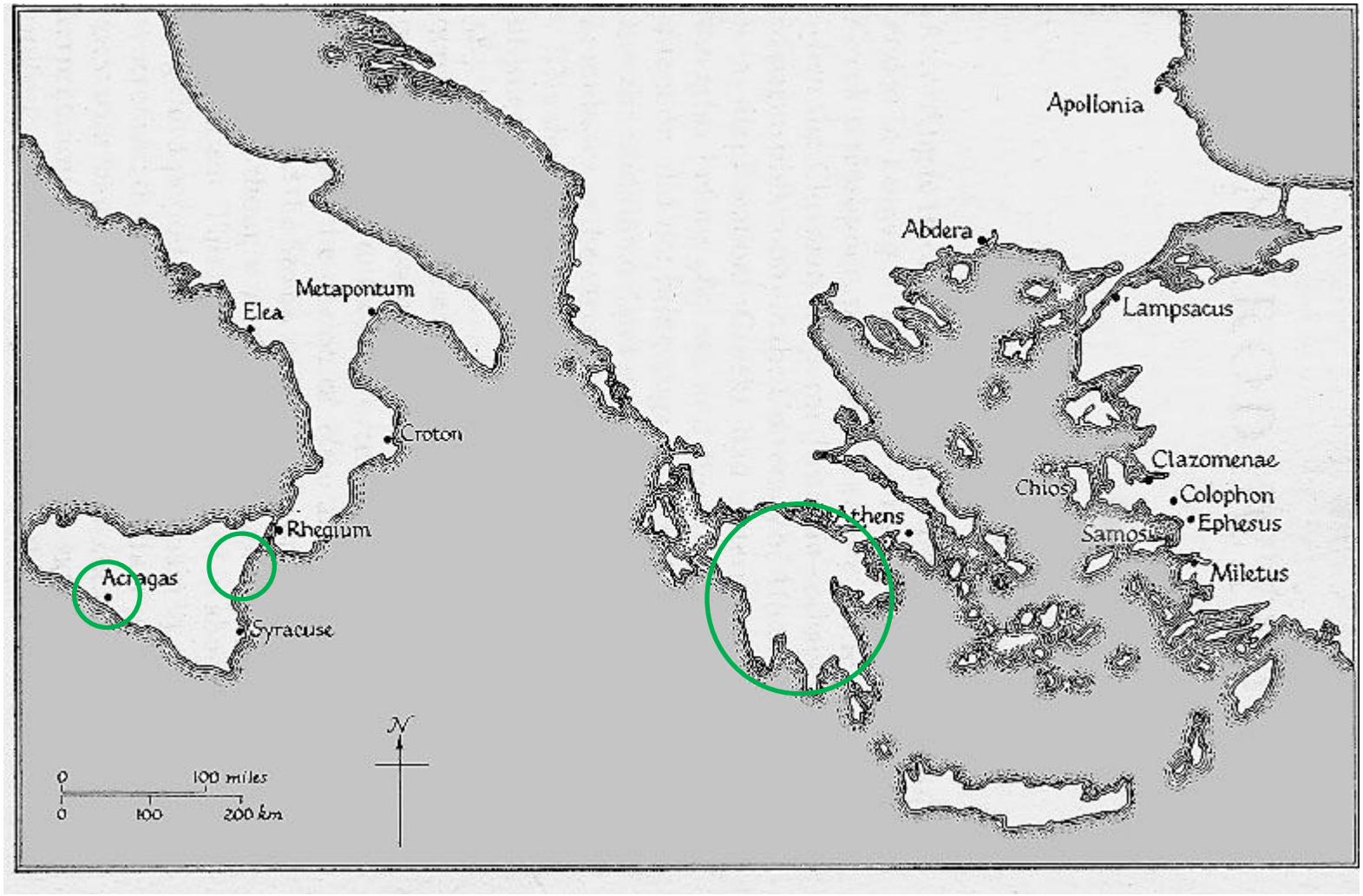
Ionia - philosophers of nature– Heraclitus
Elea –Zeno and Parmenides

Profile



Empedocles

- born - ca. 490 BC in Agrigentum – a Greek colony (Sicily)
- came from a wealhty family
- eccentric
- interested in politics (democrat)
- doctor, priest, magician, poet and philosopher
- died - ca. 430 BC (Sicily)



Greek colonies in ancient times from Barnes, Jonathan, Early Greek Philosophy (Penguin, 1987).

Profile

Eccentric clothes (purple robe with a gold belt, bronze sandals and Delphic laurel wreath)

Founder of the medical school– before him only priests and Pythagoreans were involved in medicine

Magician – he freed the city Selinunt from fever by drying the surrounding marshes, he also freed his hometown from excessive heat by opening access to fresh northerly winds by piercing the surrounding rocks.

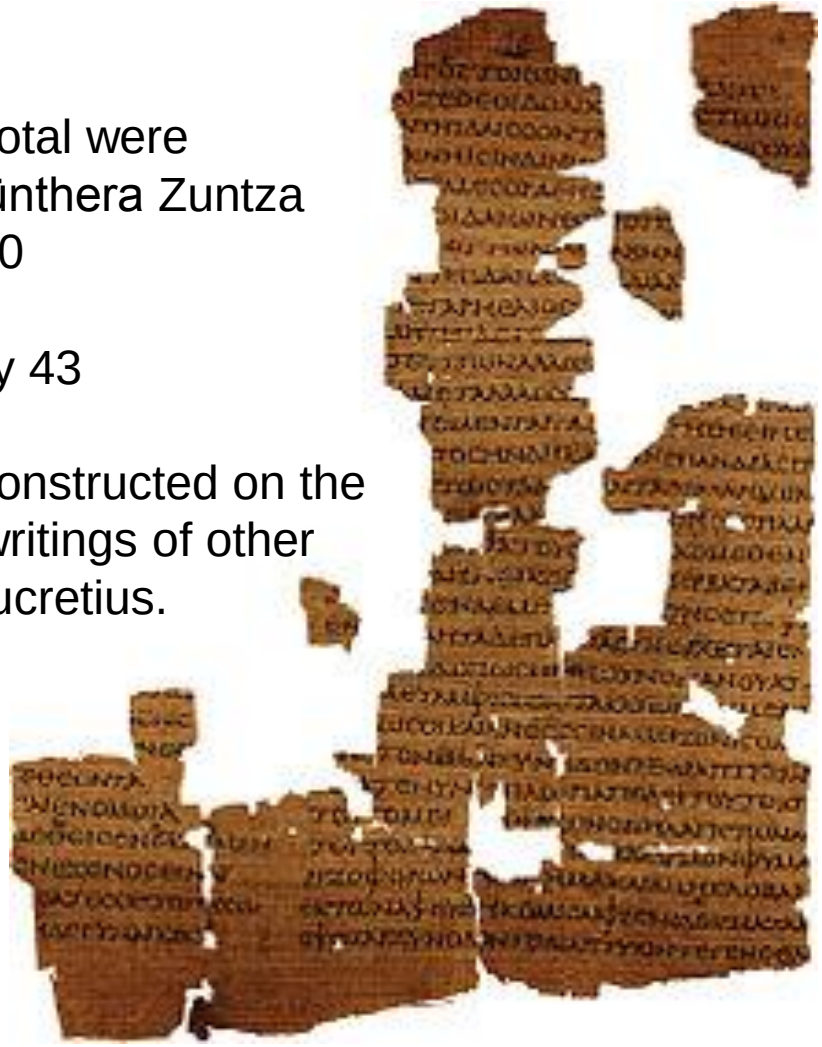
Poet and philosopher

Versified fragments of his work Περὶ φύσεως (Peri physeos, On Nature) and mystical poem Καθαρμοί (Katharmoi, Purifications)

From „ Purifications” only about 5% of total were preserved – reconstruction made by Günthera Zuntza includes only 100 lines from about 2000

Wrote tragedies - created their allegedly 43

The outlines of his philosophy were reconstructed on the basis of remittances, preserved in the writings of other philosophers - including Aristotle and Lucretius.



The most important work: poem „On Nature”
I Part – generally about the world - its forces and elements
II Part - about plants and animals
III Part–about divine things and soul

Understanding of the structure of matter

Empedocles

- the middle position between Parmenides and Heraclitus
- only simple ingredients of things are invariant
- complex things arise and disappear
- his immutability of components is not opposed to the variability of things - invariable components can be connected and disconnected; they do not change themsleves, but their systems change and things made of them arise and perish

Understanding of the structure of matter

Empedocles

Existing physicists recognized only one kind of matter: Tale-water, Anaximenes-air, Heraclitus-fire , Xenophanes and others - earth.

Empedocles began to look for simple components of matter and may be regarded as the creator of the concept of element

He adopted four qualitatively different components of the world, four kinds of matter: water, air, fire and earth. These four primary types he called "the roots of all things", then the name"Elementals" and "elements„ came to use

As the few colors in the palette of the painter created a colorful picture, so the few elements created a variety of things

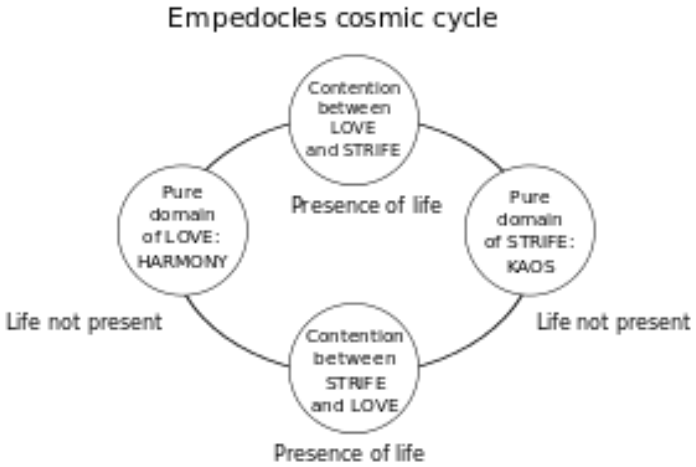
He explained the mutual behavior of the bodies by their affinities and differences between bodies treated as quantitative differences and differences in the structure

The theory of force

Empedocles

Why elements combine and disconnect?

The separation of matter and forces:
- he was looking for a force (external), which moves inert matter (the elements)
- he combined force called by the Parmenides "love" with the force of Heraclitus defined as "dispute„ into a pair of forces - love and strife



World of Emedocles is the four elements moved by the two forces. Condition of the world depends on which force is predominant.

Theory of perception

In the perception he saw activity of force , which he called „love” . Due to activity of this force similar attracts simliar and recognize similar

He believed that to an eye could see the nature, all elements must be placed in the eye

Perception is only possible in a case of direct contact of sense organ with the perceived thing. We see those things, which in terms of shape and size correspond to the pores of eye - the perception depends on the construction of organ

"Pleasure arises from what is similar in elementals and their mixture, and the pain from what is opposite„

-The study of temperaments

Summary of major accomplishments:

The first pluralist theory of matter which reconcile variabilism with the demands of Eleats

Separation of force from matter

Theory of perception

A number of valuable ideas from the fields of chemistry, biology and physiological psychology - the claim that less perfect beings arose before the more perfect (plants against animals) - as a harbinger of the theory of selection and evolution

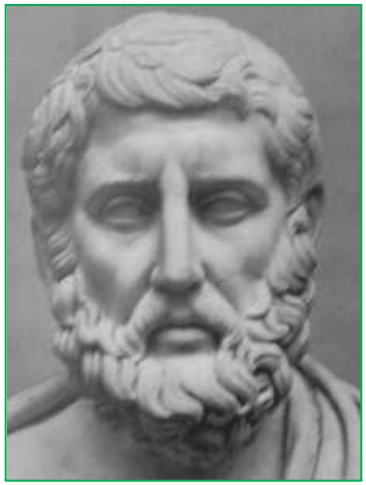
Introduced the beginnings of comparative morphology expressing the opinion that "the hair, leaves, thick feathers and scales growing on powerful body members are the same"


Empedocles.

Profile

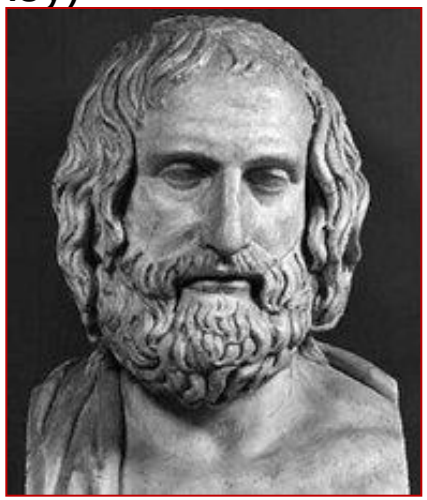
Empedocles

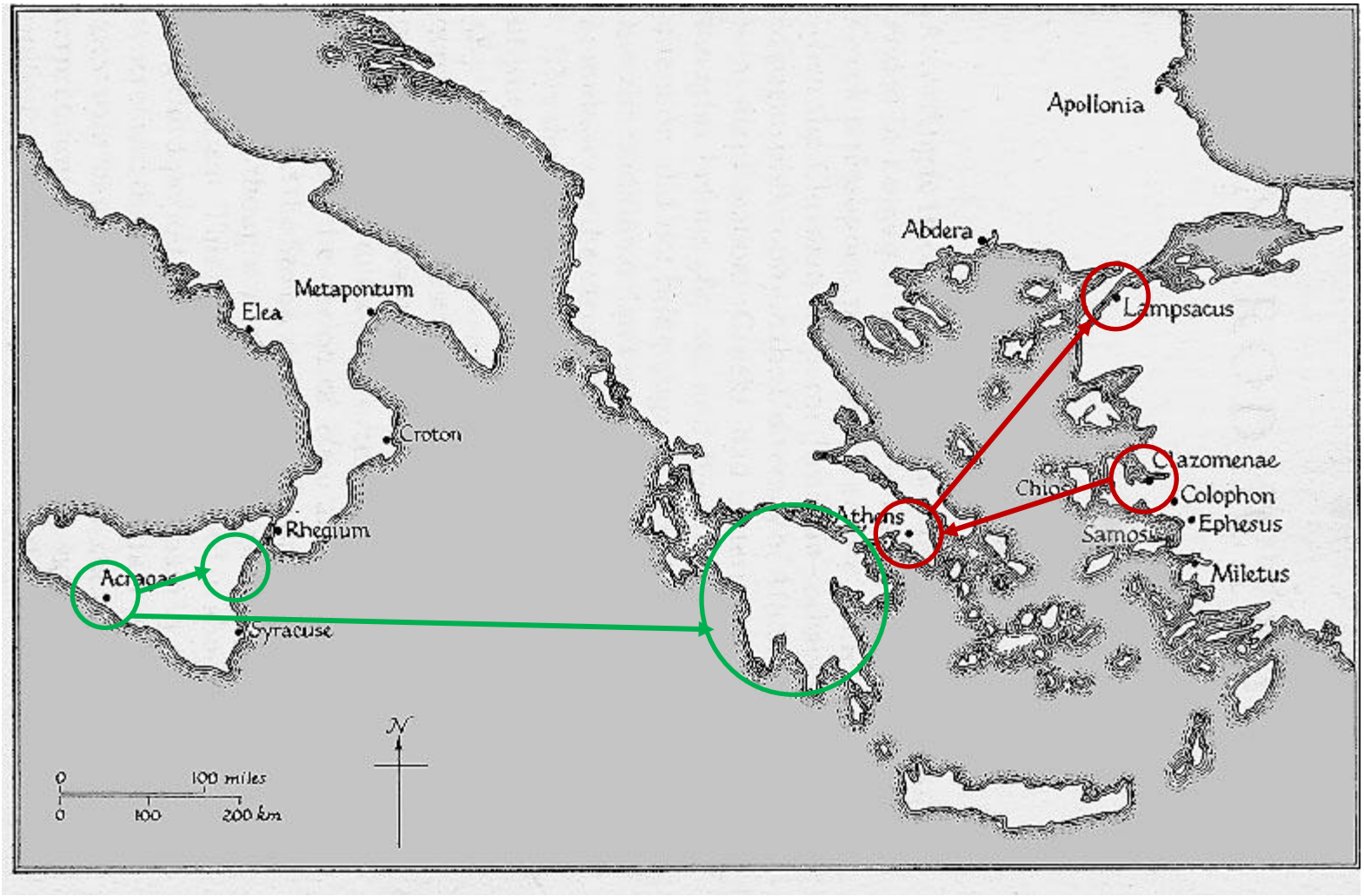
- born - ca. 490 BC in Agrigentum – a Greek colony (Sicily)
- came from a wealhty family
- eccentric
- interested in politics (democrat)
- doctor, priest, magician, poet and philosopher
- died - ca. 430 BC (Sicily)



Anaxagoras

- born - 500 BC Clazomenae– Greek colony (Turkey)
- came from a wealhty family
- modest, clearheaded
- without poetic and political aspirations
- researcher and philosopher
- died - 428 BC Lampsacus – Greek colony (Turkey)





Greek colonies in ancient times from Barnes, Jonathan, Early Greek Philosophy (Penguin, 1987).

Understanding of the structure of matter

Empedocles

The position between Parmenides and Heraclitus

Invariability of components was not opposed to the variability of things

Anaxagoras

What exists, cannot stop to be – as same as for Empedocles

The way to reconcile this assumption with the fact of variation of things was the same: the ingredients of the world are immutable, but by connecting and disconnecting they create variable systems.

Anaxagoras differs from Empedocles in the understanding of invariable components

Understanding of the structure of matter

According to Anaxagoras reality had countless number of components.
Anaxagoras stated that the elements which Empedocles considered to be the simplest are just as complex as other things

„ In everything there is a share of everything”
“All things were together.”

Even the smallest parts of matter are complex. The are no limits of divisibility

This view indicated the infinity in nature – it was prepared by the view of Zeno on the infinite divisibility, but Anaxagoras held indefinitely also in terms of quality

Understanding of the structure of matter

In all things there are all components, but all of them are not in the same proportion

In each thing we perceive only those components that prevail in it, according to them, these things are called;

Other components are also included in the items, but we cannot perceive them, similar as when we don't hear small voice in shouts of the crowd, or as we don' t see a drop of wine in a barrel of water

Our senses cannot keep up the infinite diversity and divisibility, the limit exist below which they do not reach

in connection with his theory of the world Anaxagoras came to the concept of what the psychology of recent times calls "threshold of consciousness"

The theory of force

Anaxagoras

He separated strength from matter

The matter is immobile in nature, thus only some external force is able to move it

First impulse given by the spirit

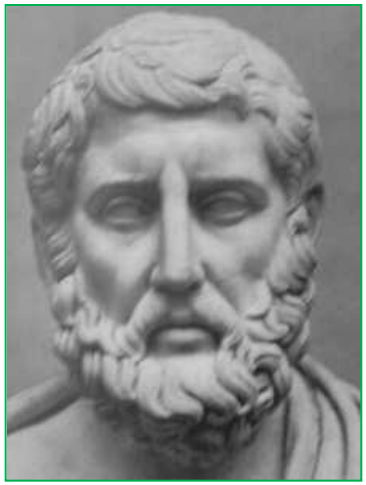
Spirit is above and beyond nature,
(it must be beyond nature to move it)

The theory of force

Empedocles

World of Emedokles are four elements moving by two external forces (love and discord).

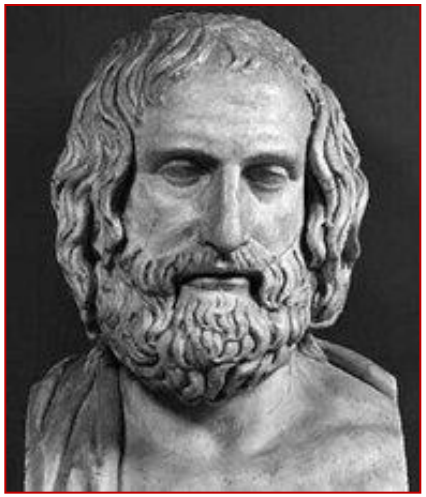
Condition of the world depends on which force is predominant



Anaxagoras

Reality has infinitely many components.

The movement of the world is the work of the spirit - a subtlest matter which do not mix with other kinds of matter. He limited the action of spirit just to movement of the world, and since the world has been moved the spirit stopped to interact with it.



Theory of perception

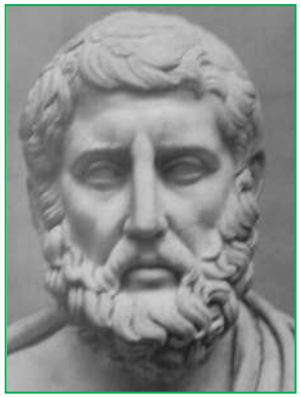
Empedocles

The first who dealt with the issue of perception

The perception possible through interaction of the force, which he called "love"

Similar attracts similar and recognizes similar.

Perception is only possible in a case of direct contact of sense organ with the perceived thing



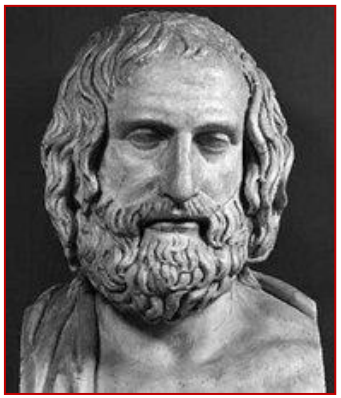
Anaxagoras

We see not what is similar to us, but what is opposite.

Generalization of observation: "What is just as cold as warm as we are, not warms us nor finches when touched.„

Further generalization of these observations led to the principle of relativity of perception.

Anaxagoras was using the principle of "threshold of consciousness". He knew that the threshold is different for different species and different organs.

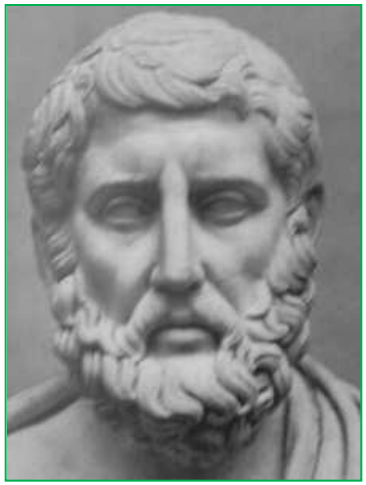


Summary of the main differences :

Empedocles

World consists of four types of matter of the four elements moving by two external forces (love and discord).

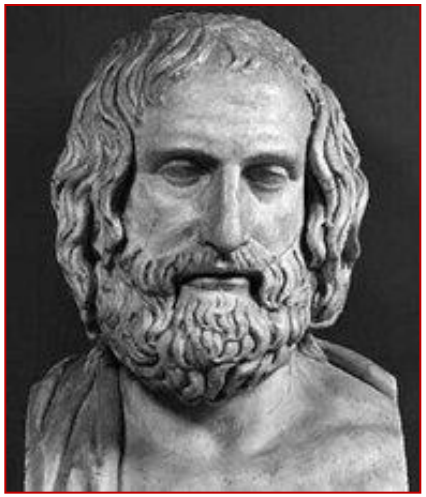
Similar attracts similar and recognizes similar.



Anaxagoras

A world made of countless types of matter driven by an outer spiritual force.

We see not what is similar to us, but what is opposite.

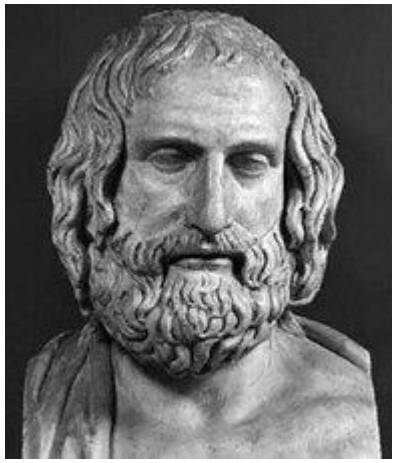


Summary of major accomplishments:

First pluralist theory of matter contacting variabilism with the demands of Eleats
Separation of forces from matter
Theory of perception
A number of valuable ideas from the fields of chemistry, biology and physiological psychology

Work *On Nature* (Peri physeos)

Empedocles



Theory of spirit, which moved the world but is beyond it
Theory of nature - qualitative and infinitistic
Theory of perception
He was the first who gave the correct explanation of the solar eclipse. Based on observations of falling meteors he concluded that the Sun and other stars had to be metal bullets.

Anaxagoras

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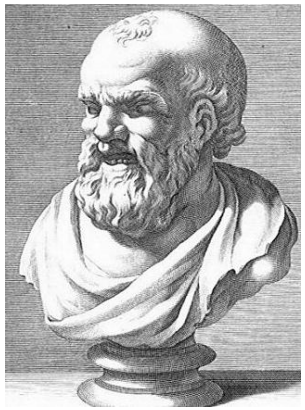
Marta Gajewska

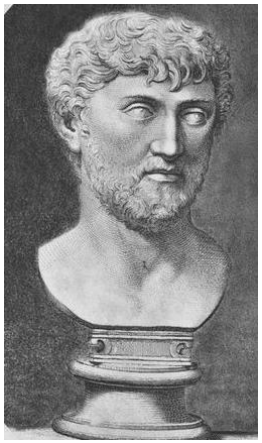
Atomic theory according to Democritus, Epicurus and Lucretius

Empedocles
Anaxagoras

400 p.n.e. 300 p.n.e. 200 p.n.e. 100 p.n.e.

Democritus Epicurus Lucretius





[5]

Democritus from Abdera "Laughing Philosopher"

- c. 460 BC – 370 BC
- author of 70 (60) works (all lost)

  in fields of: physics, astronomy, medicine, chemistry, grammar, technical works, logic, music …
- with his teacher Leucippus created **atomic theory**
- from wealthy family, inherited money spent mostly on travels to distant countries (India, Egypt, Ethiopia)
- according to Diogenes ("*Lives and Opinions of Eminent Philosophers"*)
  - modest, simple man, who lived exclusively for his studies
- <u>supposedly</u>:
  - blinded himself in order to be less disturbed in his pursuits
  - could predict future
  - died at the age of 109

[5]

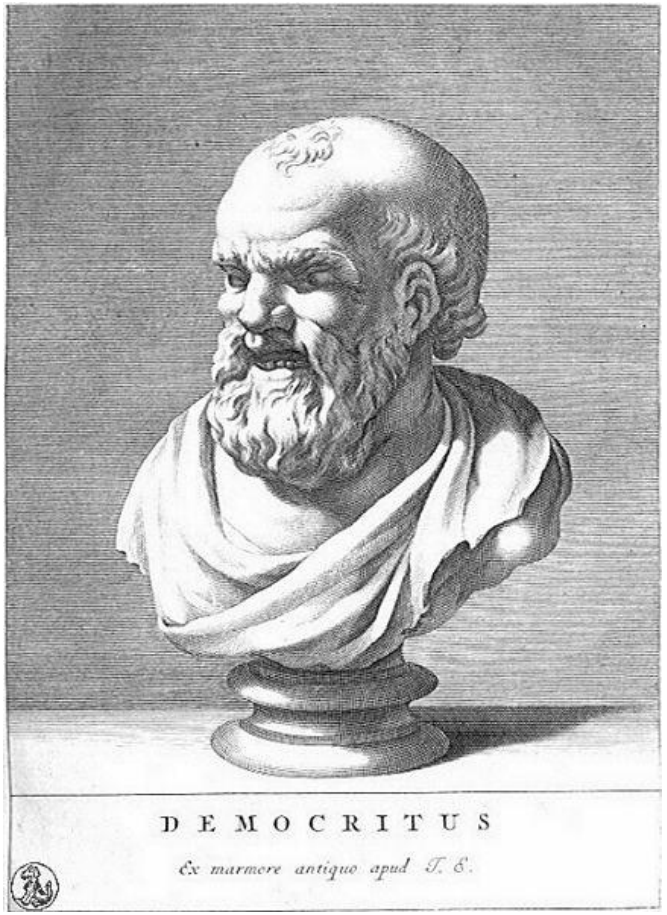
Philosophy of Democritus

➔ Atomic theory of matter

➔ Subjective theory of perception

➔Science based on inductive reasoning

➔ Ethics



[5]

Atomic theory of matter

atom from greek **ατομος** − *átomos*, meaning something that can't be divided

- Leucippus ➔ author of primal theory, main ideas and concepts
- indisputability + agreement with experiment
- foundation for science ➔ theory explained by principles and verified by experiments (according to Aristotle was a foundation of physics)
- matter is composed of atoms (corresponding to elements by Empedocles)
  - indivisible particles
  - unchanging
  - moving in space ➔ new world order
  - inspiration: dust in a beam of light

Atomic theory of matter (cont.)

”The first principles of the universe are atoms and empty space; everything else is merely thought to exist”

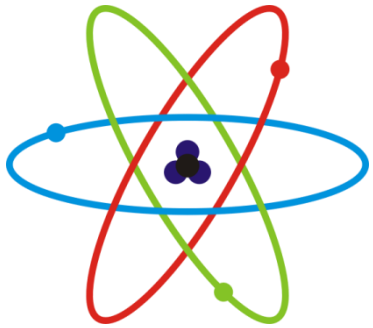
4 basic thesis:

a) whole nature is only composed of **multitude of atoms**;

b) atoms have only **quantitative properties**, not qualitative

c) **movement** (change of location in space) – general property of atoms; the one and only transformation of atoms, without any external impulse

d) atoms are placed and move **in void**



Metter is discontinuous:

„Thing exists no more than nothing”

Role of atomic theory:

1) simple rational and empiric theory, which allowed to explain many natural phenomena

2) most complete system of material philosophy

Decline of ancient times➔ opinion: real Greek philosophy is idealistic

(works of Democritus - condemned and forgotten)

Philosophy of Democritus

➔ Atomic theory of matter

➔ Subjective theory of perception (perception disqualified for cognition of reality, perceptions do not present true reality, but they are based on the configuration of atoms: e.g. white objects are composed of smooth atoms)

- **„ Sweet exists by convention, bitter by convention, colour by convention; atoms and Void [alone] exist in reality"**

- thought as well as sensation are caused by images impinging on the body from outside, and that thought as much as perception depends on images

  - sound – condensed air

  - images – parts of objects (imageries)

➔Program of causative science (but without a goal)

- all phenomena can be explained using causative thinking, e.g. the cause of astronomic phenomena is a pressure of air filling the universe;

- uniform attitude towards all of the phenomena (heaven treated like air, soul like body; soul is also composed of atoms, but small, regular and mobile)

➔Ethics

- **enlightened hedonism**, in which the good was held to be an internal state of mind (state of harmony, peace of soul) it can be achieved by use of mind (but most important is moderation)

[5]

Epicurus

- c. 341 BC – 270 BC, born on the Samos island
- at age of 35 founded his own school of philosophy in his garden in Athens „The Garden”
- according to Diogenes ("Lives and Opinions of Eminent Philosophers”):
  - author of 300 works, from which only survived „Principles”, part of „37 books on nature” and three letters (drafts of physics, meteorology and ethics)
- noble man of high morals and a simple course of life
- Even during his life he was treated (by his students) with a godly reverence

[5]

Philosophy of Epicurus

4 things make a human unhappy:

- fear of inability to achieve happiness
- fear of suffering
- fear of gods
- fear of death

- **Ethics**
  - **Hedonism** and joy of life

Happiness is to experience pleasure, unhappiness is to experience suffering

- it's enough not to suffer in order to achieve happiness; life itself is happiness (adoration of life)

- happiness does not depend on conditions but on a human being (there are no higher forces; man is responsible for his own happiness)

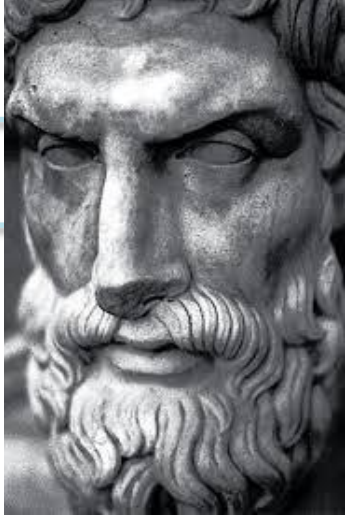
  - External pleasures (satisfaction of needs)

- physical (more basic, because connected with staying alive)
- spiritual (higher, because give more pleasure)

  - Means to achieve happiness:

- virtue
- mind

Philosophy of Epicurus (cont.)



[5]

- **Physics** ➔ it's not worth to investigate nature just for itself
  - **Causality** (mechanistic theory)

    - no higher (godly) force ; ~~fear of gods~~

    - motion of atoms is only caused by their weight;

    - world as a result of material forces which act mechanically
  - **Soul** (bodily, destructible; liquid matter spread out through body) ~~fear of death~~
  - **Materialism** (**atomistic** theory in main principles corresponding to Democritus' ideas)

  Differences: sensual qualities are not subjective (they form in groups of atoms)

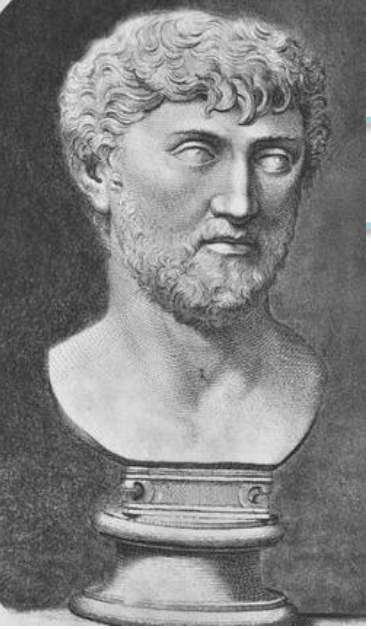
- **Logic** ➔ enlightenment is a condition required to achieve happiness➔ it is particularly important to distinguish between a truth and a lie

Cult of life
+
Desire of happiness

Sober state of mind (trusts only for things, which are directly given)

Epicureanism

- acknowledges only temporal goods
- human is responsible for his own happiness
- peace is a perfect state of human
- enlightenment is the best mean of mind
- all being is bodily (atomic)
- there are no supernatural forces
- Causes (acting mechanically) determine incidents



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Lucretius (Titus Lucretius Carus)

- c. 99 BC – 55 BC
- Roman philosopher and poet
- only one known work - poem „De rerum natura”
  - masterpiece of Latin literature
  - 7500 verses, 6 books
  - Lecture of epicurean philosophy
  - currently considered as strikingly contemporary work, being one of the impulses leading to development beginning from Renaissance until today
- according to Saint Jerome:

became mad after overdosing of a „love nectar”, wrote during flashes of conscience, committed a suicide at the age of 44

(1)

T. LUCRETII CARI

DE

RERUM NATURA

Liber Primus.

AENEADUM genetrix, hominum divumque voluptas,
Alma Venus, cœli subter labentia signa
Quæ mare navigerum, quæ terras frugiferenteis.
Concelebras: per te quoniam genus omne animantum
Concipitur, visitque exortum lumina solis:
Te, Dea, te fugiunt venti, te nubila cœli,
Adventumque tuum: tibi suaveis dædala tellus
Summittit flores, tibi rident æquora ponti,
Placatumque nitet diffuso lumine cœlum.
Nam simul ac species patefacta est verna diei,
Et reserata viget genitabilis aura Favoni:
Aeriæ primum volucres te, diva, tuumque
Significant initum perculsæ corda tua vi.
Inde feræ pecudes persultant pabula læta,
Et rapidos tranant amneis: ita capta lepore;
Illecebrisque tuis omnis natura animantum

B

Te

[5]

„De rerum natura”

(continuation of atomic theory)

[6]

1) Invariant constituents of the universe: atoms and void

   - fundamental principles of epicurean atomic theory

2) How atoms explain phenomena

   - detailed description of properties and behaviour of atoms (constant motion, in void without obstacles)

3) Nature and morality of soul

   soul = *anima* (ghost, spread out in the body) + *animus* (mind, command centre)

4) Phenomena of soul

   simulacra – „images” of an atomic thickness, fast as a lightning, which flow out from a surface of objects get to eyes or mind

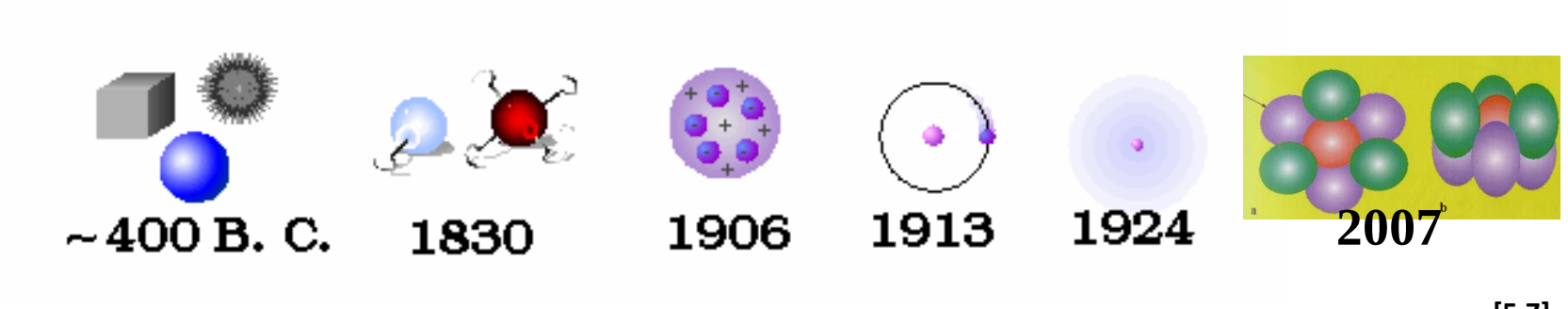
5) Cosmos and its morality 6) Cosmic phenomena

   - universe is a transient group of atoms; there is no causative force

Ancient atomic theory vs. atomic theory now

Differences:

1) Unlimited amount of types of atoms
2) Atoms differ from each other only in mathematic-geometric properties
3) Atoms are kept together by hooks, holes, branches



[5,7]

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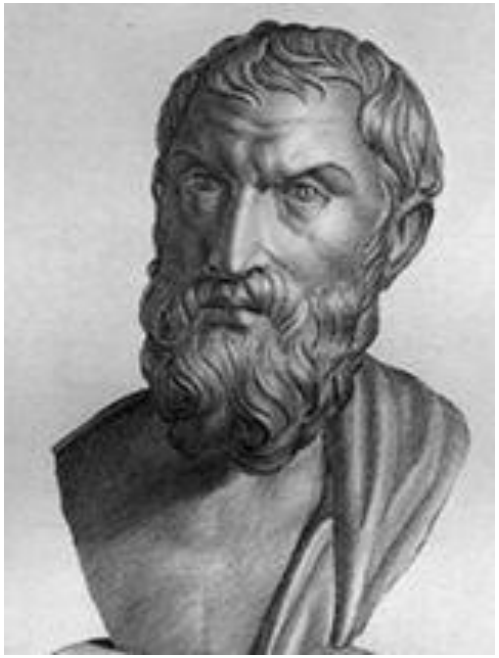
Agnieszka Jelonek

Bronze Age, Iron Age – from the history of material culture

news.discovery.com

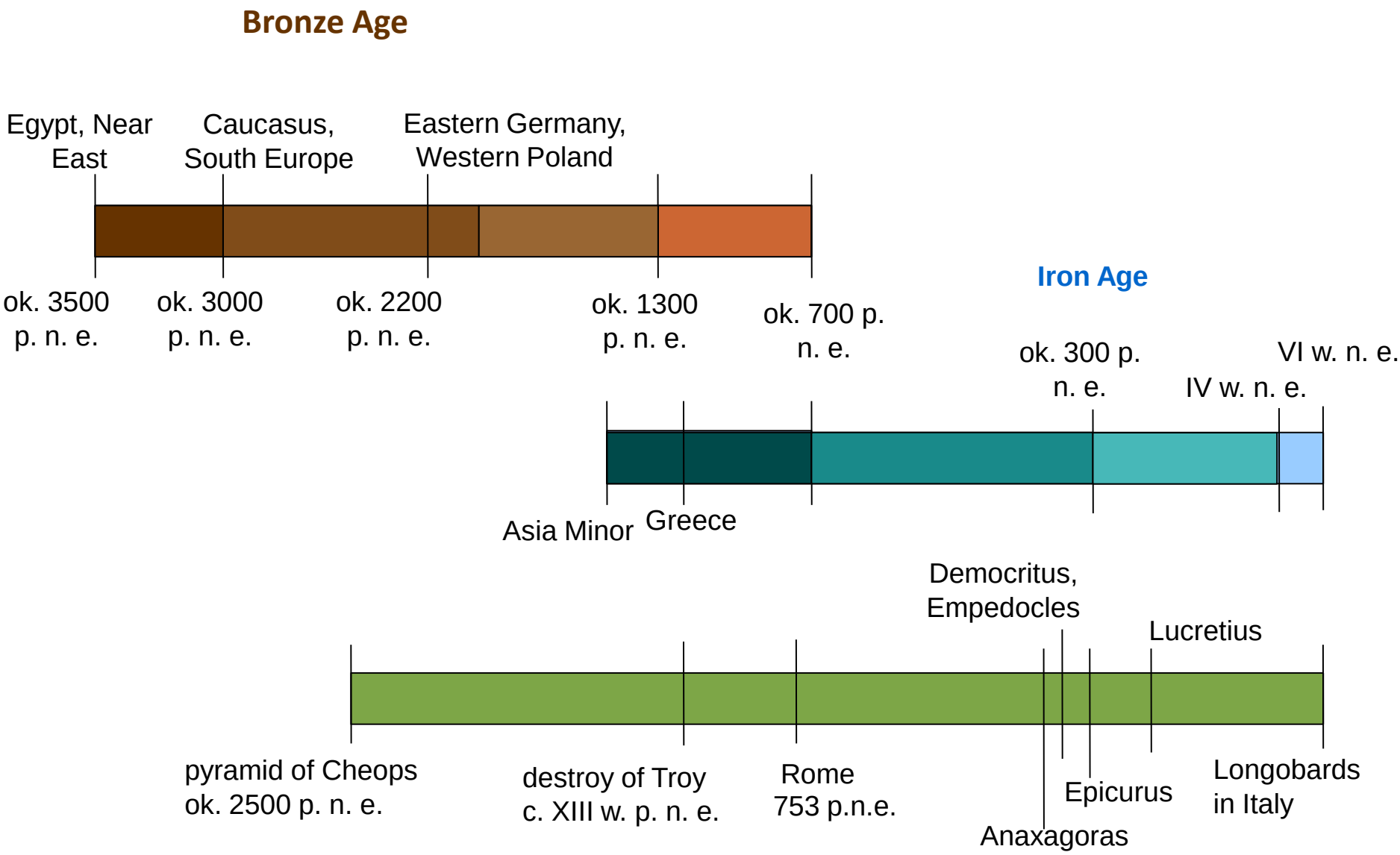
STONE AGE – BRONZE AGE – IRON AGE

- names of the historic periods were given after the main material used to make implements at that time
- Lucretius (c. 99 - c. 55 r. p. n. e):



Chronology

- different time frame for different regions



Metals in human life

- C. J. Thomsen in 19th century propagated (after Lucretius) the three-age Stone-Bronze-Iron system
- metals known to the oldest civilizations:

gold, silver, copper, iron, tin, lead and mercury

- metals' properties that interested ancient peoples:

- colour, lustre

- capability to reflect the light

- acoustic properties

- toughness, durability and plasticity

- facility of binding some metals by welding

- possibility to reuse metals after recast

- discovery of metals and their applications accelerated the development of civilisations

Bronze

- alloy consisting of a copper – c. 90% and tin – c.10%
- copper - widespread in nature
- tools made of bronze were harder and more durable than their copper predecessors
- ability of casting copper with different alloying agents – the beginning of casting
- metal ores at first were opencast mined, then underground mined
- casted tools: axes, chisels, hammers, hoes, knifes, jewellery, weapon

pl.wikipedia.org

Bronze Age

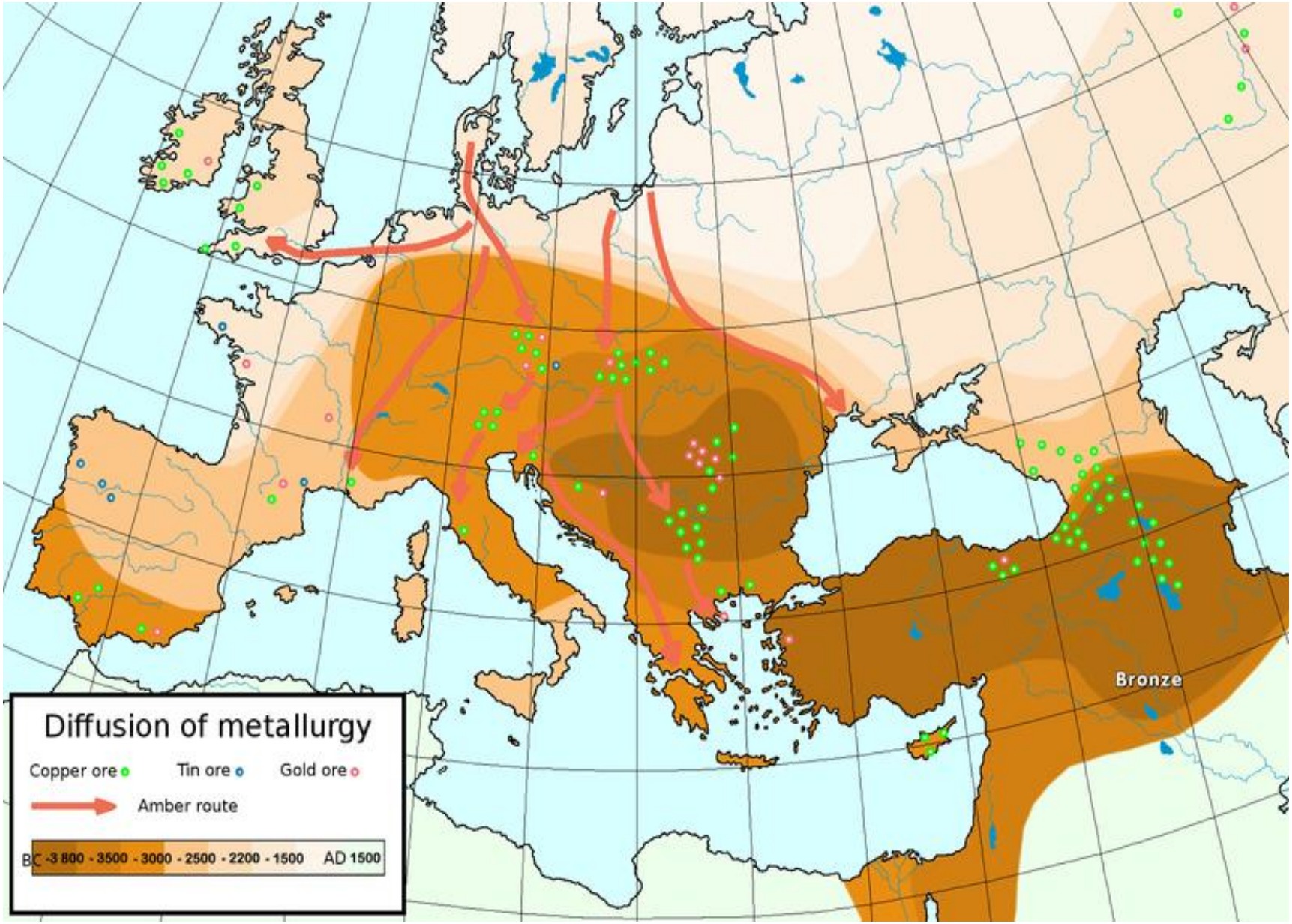
- economy mainly based on agriculture, cattle farming and herding

- production of bronze implements was limitet by a feedstock availability – maldistribution of metal ores

↓

Bronze Age: increase of exchange and development of far-ranging trade

- significant development of reciprocal trade contacts between communities in Europe ⟶ cultural unification (clothing, customs and religious beliefs), accelerated spreading of technical news
- development of different branches of manufacturing (also metallurgy) and trade ⟶ diversification in communities and emergence of aristocracy class


Diffusion of metallurgy
Copper ore
Tin ore
Gold ore
Amber route
BC -3 800 - 3500 - 3000 - 2500 - 2200 - 1500 AD 1500
Bronze

3rd millenium BC: the earliest cultures of Bronze Age in Europe

wynalazki.slomniki.pl

- the first centers in Europe, where people mastered the technology of metalworking (gold, copper and bronze) , developed in Caucasus and Aegean See zone

↓

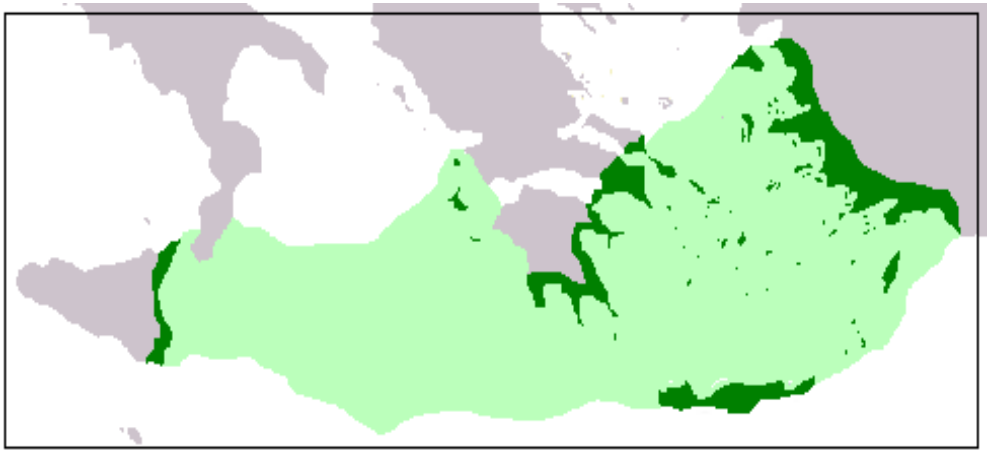
high level of economic, technological and social development

↓

in 2nd millenium BC - influence on development of new cultural centers in Europe

Early Minoan civilisation

- trade with Egypt, Syrian Coast, Cyprus, Greek Coast and Aegean Islands



- potter's wheel
- engraved gems with pictographs - early writing system

es.wikipedia by Mexicano

2000-1300 BC Early Bronze Age

geographical range: Greece and Aegean Islands

<u>Minoan civilization:</u>

- continuo of early Minoan civilization
- well developed maritime trade and significant role of fleet
- well developed architecture, water available to the upper class through clay pipes, sewerage

Mycenaean Greece

- geographical range: Greece and Aegean Islands

- big cities - well fortified and palaces

Unetice culture

- geographical range: Moravia, Czech Republic, Slovakia, Germany, Poland (Silesia, Greater Poland, Lubusz Land, Pomerania and Kujawy)

- houses were constructed of wood, with gable roof, rectangular in plan

- economy based on agriculture

- well developed metallurgy

- mostly skeletal inhumations (flat graves)

1300-700 BC Middle Bronze Age

Lusatian culture

- geographical range: Polish lands in the Odra and Vistula basin, parts of Czech Republic, Saxony with Lusatia, parts of Slovakia and Volhynia

- people of Lusatian culture dwelt open villages and fortified settlements on hilltops or in swampy areas (for example Biskupin)

- houses were rectangular in plan

- well developed casting

- burials by cremation

pl.wikipedia.org/

12th – 8th century BC - Greek Dark Ages

- lack of archaeological evidence and writing sources
- fall of the Mycenaeans
- reduction of the population of Greece
- impoverishment of the material culture
- limited contact with the outside world

http://en.wikipedia.org

Iron Age

- in the beginning meteoritic iron was used
- relatively expensive iron was used mainly to manufacture jewellery
- afterwards iron was used also in manufacturing tools and weapon
- Iron Age coincided with changes in society, including: religious beliefs, art and agricultural practices
- in the early stage of Iron Age – important role of Greek culture (Greek colonisation)
- influence of Roman culture
- migration period

Iron

- the most popular type of iron in antiquity – so-called bog ore and marsh ore, in which the iron content varied from 30% to 50%
- in the beginning the ores were opencast mined, then underground mined
- iron was obtained by thermal separation of raw material from impurities

Technology

- iron smelting was originally produced in open furnaces, then in bloomeries
- iron ore was placed alternately with charcoal in bloomery, furnace was heated to 1300°C, the iron bloom with charcoal inpurities was obtained
- to eliminate impurities the bloom was reheated and hot hammered
- in order to obtain much harder product, wrought iron was heated in the shaped piece in a bed of charcoal for some time, and then quenching in water or oil
- iron implements – much more durable than bronze implements
- forging – possibility of forming even complicated shapes

pl.wikipedia.org/

Iron Age

Period of Greek influence

- science and art of ancient Greece

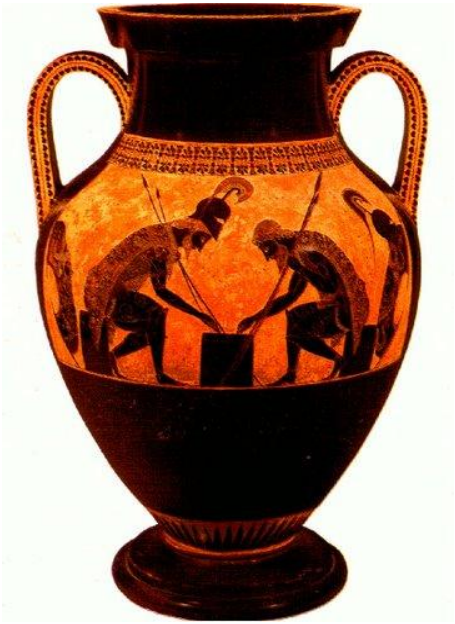
(alphabet, philosophy, literature, architecture, etc.)

- society organised in *polis* – city-states

- polytheism

- ancient Greek colonisation

- deveopment of trade and craft



podroze.gazeta.pl butterfield-reignbeau.blogspot.com lastinn.info

700-300 BC Early Iron Age

- Pomeranian culture

- geographical range: almost entire area of modern Poland

- agriculture and farming economy

- architecture: few hill forts and small open villages

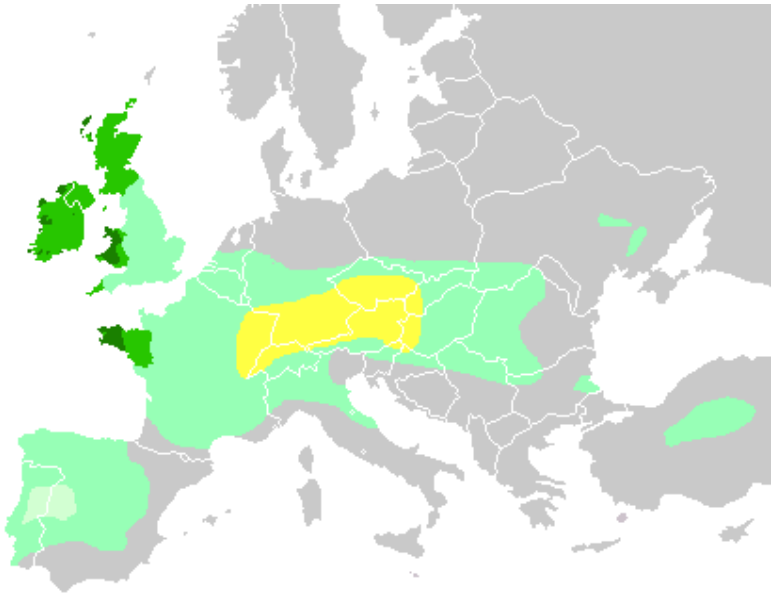
- material culture is characterised by necklaces of multiple bronze rings, metal, horn and bone implements (pins, combs, brooches) and amber jewellery for exchange trade

- burials by cremation (the face-urns)

Celts – La Tène culture

Celts formed as a separate group of tribal societies in 6th century BC on the area spread from Champagne, across Bavaria to North-west Austria

- expansion of Celts culture



- 5th- 6th century - the last stage of Celtic expansion

pl.wikipedia.org/

Celts

- Celtic tribes mastered the technology of obtaining an iron from a bog ores
- high level of Cetic metallurgy contributed to military success of Celtic warriors who were armed with iron swords
- iron plough enabled to reform agriculture (deep ploughing)
- blacksmithing tools used by Celts remain in their unchanged form till today

Iron Age

Period of Ancient Rome influence

- Roman conquests in Europe
- assimilation of conquered cultures: adaptation of Roman style of clothing, fight technique etc.
- development of political and economical contacts
- development of trade and craft (amber trade route)
- spreading of technical news (potter's wheel, lathe)

Iron Age

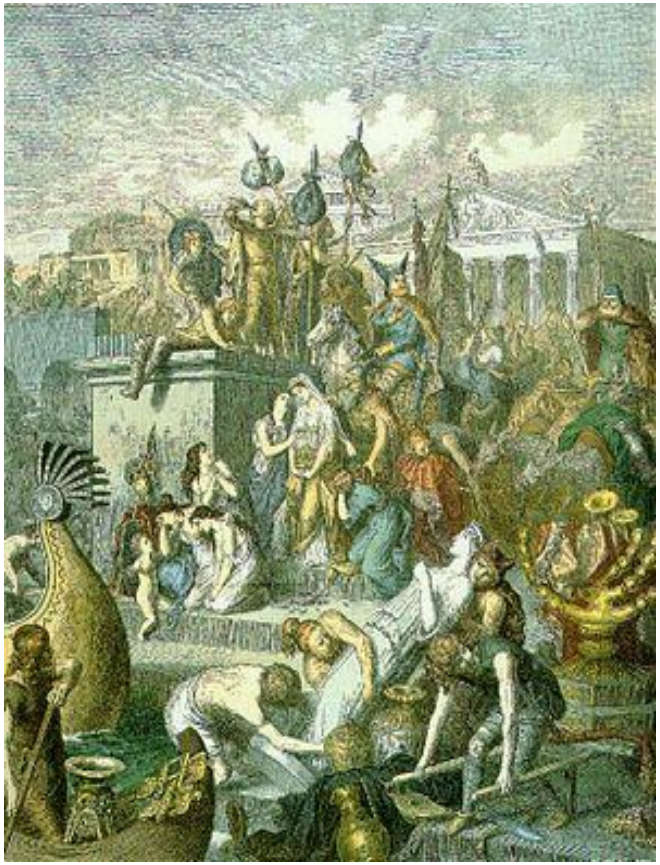
The great migrations

- intensified migration of barbarian tribes, especially Huns and Germanic peoples, to the territory of Roman Empire

- ethnic changes on the large area of Europe

- end of the Antiquity and fall of the Roman Empire

- from the chaos of migrations the foundation of nation states emerged, which continue their tradition during the Middle Ages up till contemporary times



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Piotr Bobrowski

Alchemy

Alchemy

- Alchemy: ar. *al-chimija,* gr. *chymeia (joining, alloying)*
- Alchemy – philosophical tradition and protoscience contributed to chemistry and medicine, joining the exoteric and esoteric aspects of the knowledge about universe

Goals pursued by alchemy

- philosopher's stone (*lapis philosophorum*) – substance believed to be capable of turning common metals into noble metals, obtained during the Great Work (*Magnum Opus*) process

- panacea – universal remedies to cure all diseases

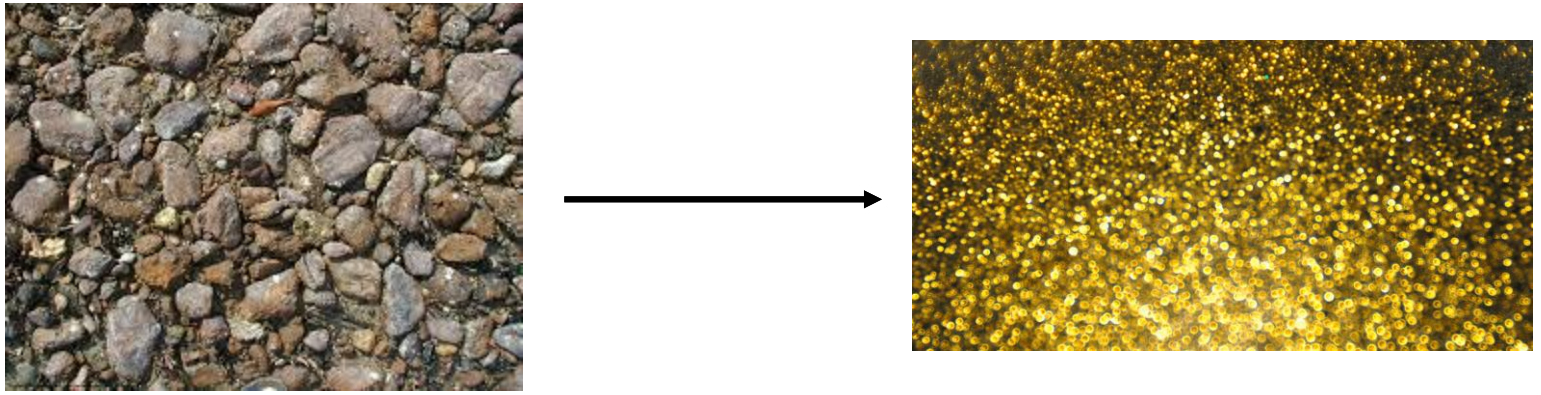
- elixir of life (immortality) – mythical potion which grants eternal life (or youth), sometimes said to be able to create life

Additional concepts

- floghistone – mythical substance present in materials, responsible for flammability and corrosion
  - ($C+Fe_2O_3$ -> $Fe + CO_2$)

- energy (*vis vitalis*) – the energy of life, the capability of living organisms to create organic compounds

- transmutation – conversion of one element into another



Antiquity

- Egypt:

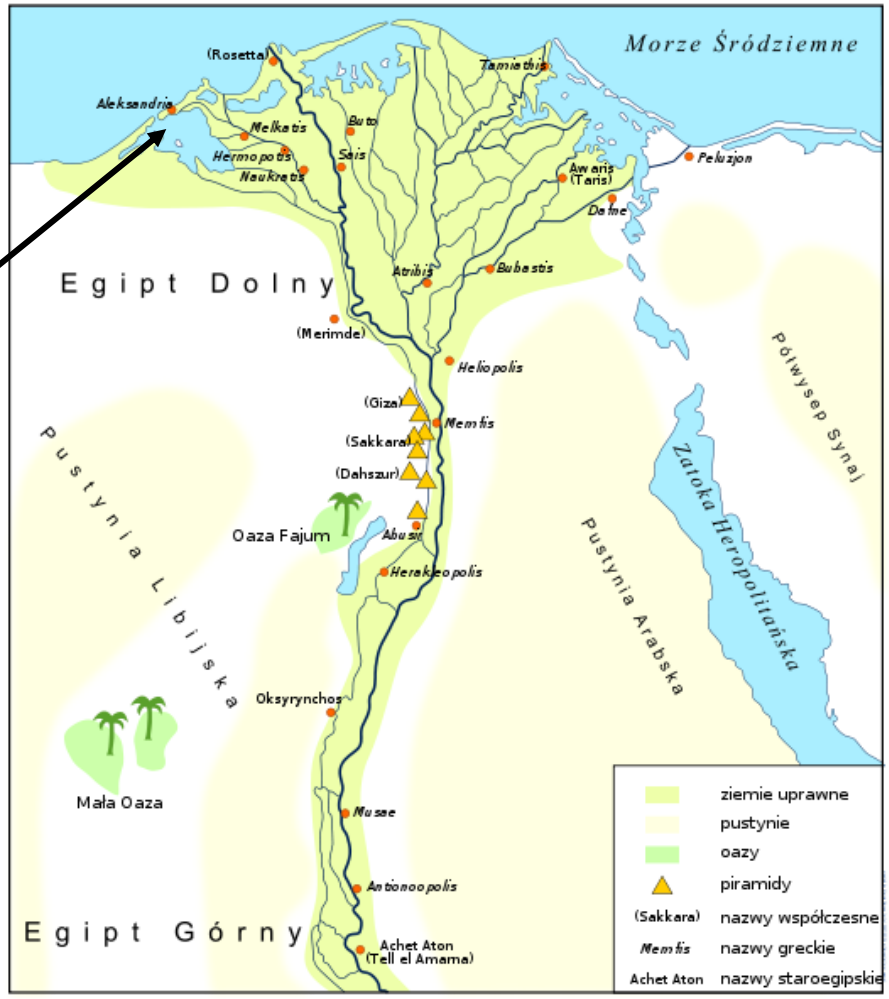
- embalmment of bodies

- Thot, god of arts, magic, science and judgment of the dead

- Hellenic Egypt:

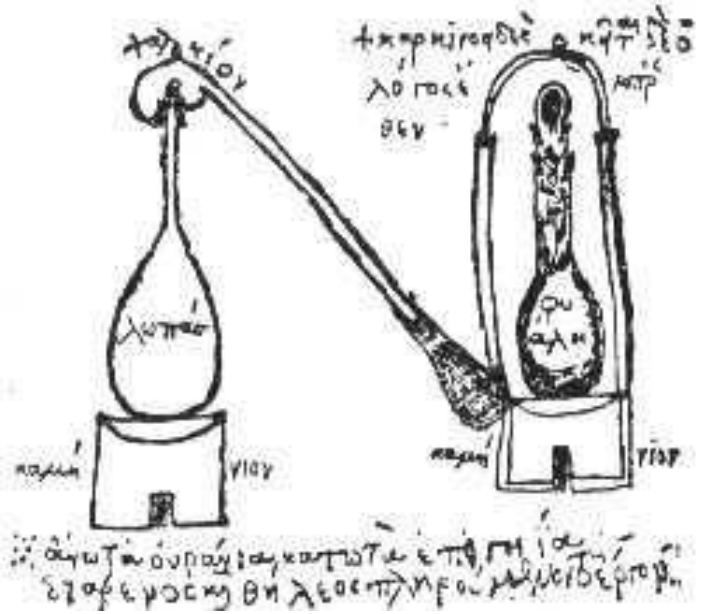
- Ptolemean dynasty (323-30BC)

- Hermes Tresmegistos (*Tabula Smaragdina, Corpus Hermeticum*)



Antiquity

- Bolos of Mendes (III c. BC) – the first alchemist:
  - transmutation of metals: Pb –> Au
  - metals: fire + water
  - changing colors of noble metals (purple)
- Ptolemy II Philadelphos (II c. BC):
  - search for panacea and elixir of life
  - Academy of Alexandria
- Zosimos of Panapolis (III c. BC):
  - first distillation of alcohol
  - encyclopedia of alchemy (28 tomes)
  - lead acetate
- Maria Prophetissa (the Jewess) (I c. BC):
  - distillation
  - HCl



Mid-ages

China

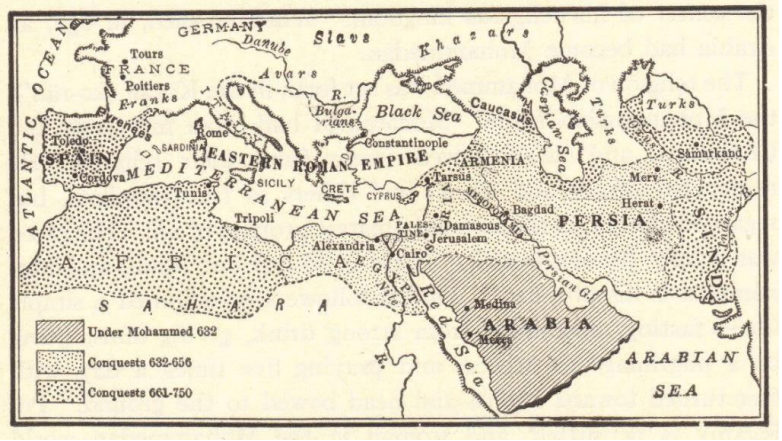
- Ge-Hong (III c. AD):
  - searching for elixir of life
  - transmutation: Hg -> Au, Cinnabar (HgS) -> Au
  - poison based on Hg
- gun powder:

sulfur + charcoal + niter

Mid-ages

Arabia

- Jabir ibn Hayyan (Geber) (VIII c. AD):
  - introduced a scientific and experimental approach to alchemy
  - $2PbCO_3 \cdot Pb(OH)_2$, NH_4Cl
  - acids: acetic, citric, nitric
  - Hg is a metal, though it's liquid
  - Hg + S -> Au
  - *Takwin* – synthetic life



- Muhammad ibn Zakaria Razi (Rhazes) (IX c. AD):
  - application of gypsum for fixing broken bones
  - description of smallpox and measles
  - Hg + S + NaCl -> Au
  - author of at least 20 tractates on alchemy

Mid-ages

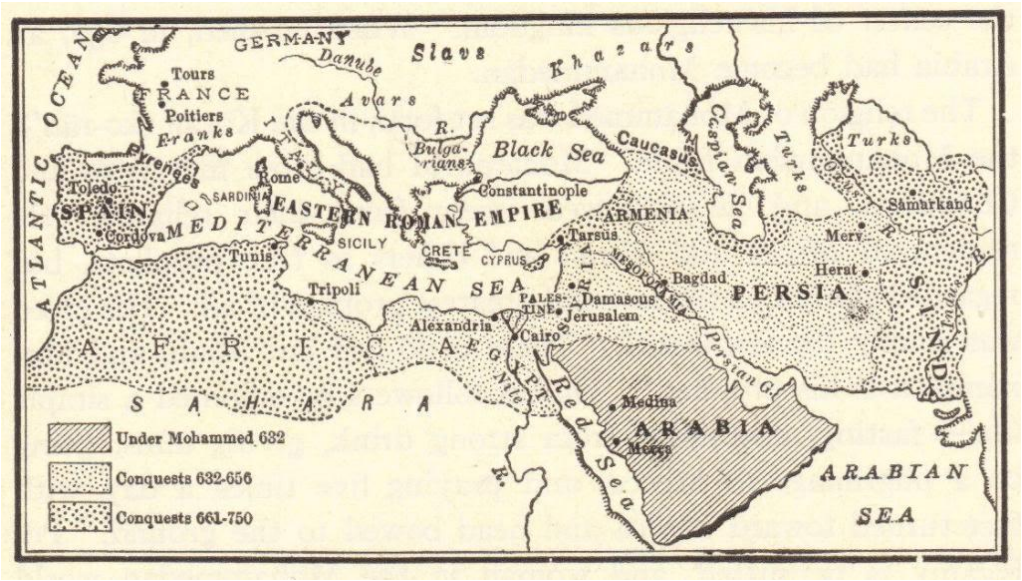
Arabia

- Abu Ali Husain ebn Abdallah Ebn-e Sina (Avicenna) (X-XI c. AD):
  - the most famous Arabic alchemist
  - author of ca. 450 books on medicine and alchemy
  - introduced leeches to medicine
  - the theory of epidemics as the pollution of the air, suggested quarantine
  - *Al-Qanoon fi al-Tibb* (The Laws of Medicine) - standard medical text in Europe and the Islamic world until the 18th century

Mid-ages

Europe

- Gerard of Cremona (XII AD):
  - *Tables of Toledo*
  - Euclid's *Geometry*
- Adelard of Bath (XII AD):
  - introduced Arabic numerical system

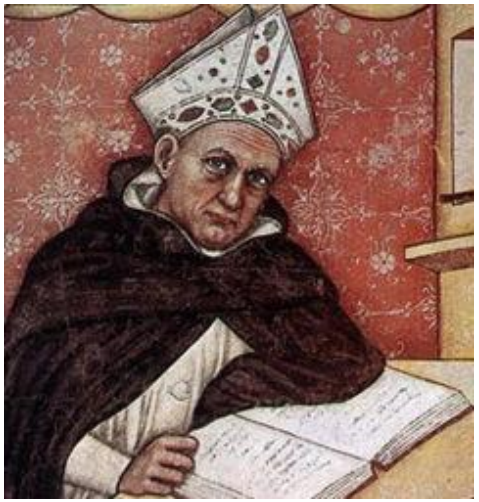


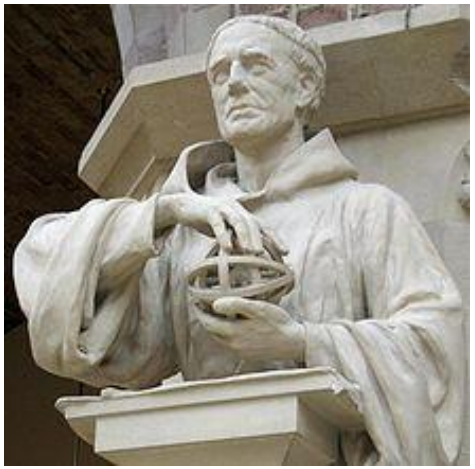
Mid-ages

Europe

- Albert of Lauingen (Albertus Magnus) (XIII AD):
  - saint, bishop
  - As_2O_3, sulfuric acid, nitric acid
  - android

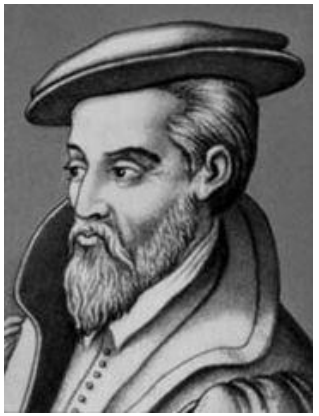
- Roger Bacon (XIII AD):
  - modern scientific method
  - forerunner in calendar reformation
  - invention of gunpowder





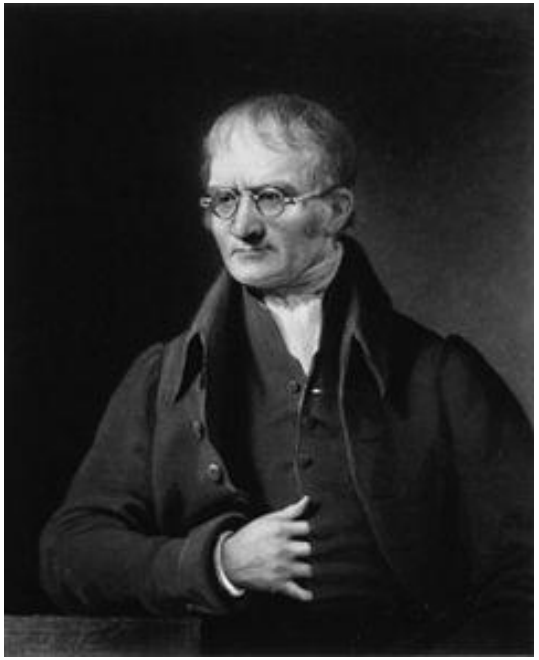
Modern age

- Georg Bauer (Agricola) (XVI AD):
  - *De re metallica*
  - „the father of mineralogy”
  - fire-setting
- Phillippus Aureolus Theophrastus Bombastus von Hohenheim (Paracelsus) (XVI AD):
  - *De medicina*
  - Iatrochemistry, toxicology (Hg, opium)
- Andreas Libau (Libavius) (XVI AD):
  - *Alchymia*
  - crystallization
  - aqua regia
  - HCl, SnCl, $(NH_4)_2SO_4$



Decline

- Robert Boyle (XVII):
  - *The Skeptical Chymist*
  - modern experimental methods
  - Boyle's law
  - wish list: prolongation of life, flight, under-water ships, transplantation
- Antione Lavoisier:
  - quality -> quantity (soichiometry)
  - role of oxygen in combustion
  - hydrogen, sulfur
- John Dalton:
  - Daltons law
  - atomic theory
  - colour blindness



Alchemy in Poland

- Lorentz Dhur (Jan Twardowski) (XVI AD):
  - alchemist, astrologist
  - medic of Sigimund Augustus
  - summoning of ghosts (Barbara Radziwiłłówna)
  - assasinated in Mystki-Rzym
- Olbracht Łaski:
  - alchemist
  - voivodenship of Sieradz
  - John Dee
- Michał Sędziwój:
  - alchemist
  - *Traktat o Kamieniu Filozoficznym* (*Novum Lumen Chymicum*)
  - *Promptuarium Alchemiae ander Buch*

Alchemy in Poland

- Sigimund II Augustus:
  - Aleksnader Suchta, Stanisław Dwojna, Baltazar Smosarski, Piotr Proboszczowicz, Marcin Fox, Kasper Górski, Jan Twardowski
- Stefan Batory:
  - Wawrzyniec Gradowski, Łukasz z Kościelca, Rupert Finck, John Dee
- Sigimund III Wasa:
  - multiple alchemical laboratories, Michał Sędziwój

Nuclear transmutation

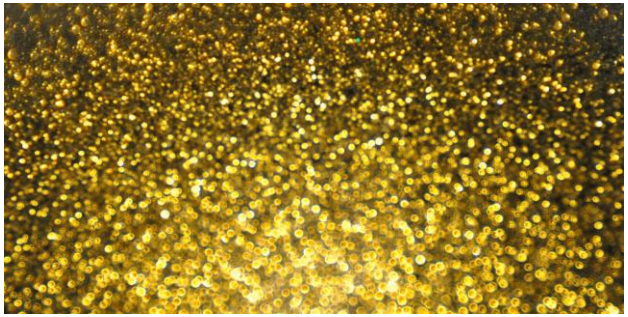
- Transmutation of Hg into Au (1941):

$$^{198}_{80}\mathrm{Hg} + {}^{1}_{0}\mathrm{n} \rightarrow {}^{198}_{79}\mathrm{Au} + {}^{1}_{1}\mathrm{p}$$

$$^{199}_{80}\mathrm{Hg} + {}^{2}_{1}\mathrm{D} \rightarrow {}^{197}_{79}\mathrm{Au} + {}^{4}_{2}\mathrm{alfa}$$

$$^{200}_{80}\mathrm{Hg} + {}^{1}_{1}\mathrm{p} \rightarrow {}^{197}_{79}\mathrm{Au} + {}^{4}_{2}\mathrm{alfa}$$

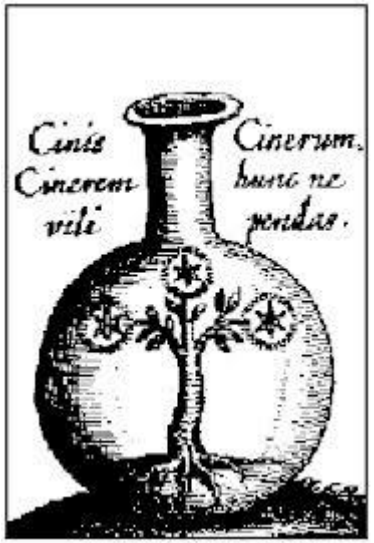
- Bi -> Au (1980)
- production of rare and expensive elements:
  - ^{100}Mo -> ^{101}Ru
  - ^{102}Ru -> ^{103}Rh
  - ^{186}W -> ^{186}Re
  - ^{187}Re -> ^{188}Os
  - ^{192}Os -> ^{193}Ir
  - ^{193}Ir -> ^{194}Pt



Alcohol

- Alexandria (III c. BC)
- Arabs learned the distillation, but they did not drink it (*Al-Qur'an*)
  - production of poisons (methanol), medicine
- rediscovered in Europe (Salerno, XII c. AD)
- XIV c. AD: national drinks in Europe

Summary

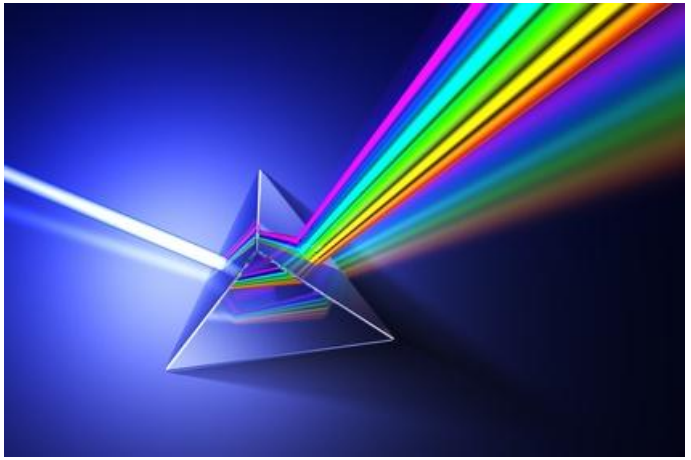


- protoscience:
  - chemistry
  - pharmacy
  - physics
  - astronomy
- development of chemical apparatus
- methods for obtaining various elements and compounds

Grażyna Kulesza and Jagoda Poplewska

Between Chemistry and Physics

VS.



Definitions

Chemistry (Greek χημεία - chemeia) science that studies the nature and properties of the substances, and in particular, the transformations taking place between them.

The nature and properties of the substances are also examined by the **physics**. Chemistry and physics interfere with each other, and often it is difficult to precisely determine where one field ends and the other begins. Chemistry, like physics is a central nature science. Both of these sciences are the basis of all other life sciences - biology, geography, metallurgy and many others.

Physics (gr. φύσις physis - "nature") - nature science that studies the properties and transformations of matter and energy, and the interactions between them.

Physics is closely linked to other natural sciences, especially **chemistry**. Chemists take the theories of particle physics and related compounds (quantum mechanics, thermodynamics) and use them to create theories in their own areas of research. Physics has a special place in the nature sciences, because it explains basic relationship existing in nature.

All divisions are human inventions, and all are quite artificial. The surrounding us nature can not be divided equaly into different subject areas - constitutes the entire and that is the way how it should be treated. Is it true?

Definitions

The physical transformation is present (physical phenomenon) when before and after the process the matter is identical to the amount and method of interconnection between the atoms comprising it. Such phenomena is involved in physics (electrical phenomena, magnetic, optical, mechanic - or a description of the motion of matter, etc.)
If, during the process, there is change of the atoms connection between them, new particles are formed (e.g., from carbon and oxygen the carbon dioxide molecule is formed) then such phenomena are chemical reactions and determine the essence of chemistry.

Evolution of chemistry

Chemistry is a nature science that deals with the transformations of substances considered in various aspects in terms of energy, structure, kinetics, reaction mechanisms, equilibrium states, as well as their importance in nature and society.

- experimental study (however, the results of its research can be largely expressed numerically and in the form of quantitative models-known to science)
- allow a deeper understanding of phenomena observed in nature and technical environment
- allows you to protect humanity from the negative effects of spontaneously developing civilization

Evolution of chemistry - Ancient and the Middle Ages

Origins of carrying out chemical reactions can be discerned already in ancient times, and theoretical reflections appeared much later. At the beginning they were merely intuitive.

Empedocles (5th century BC):

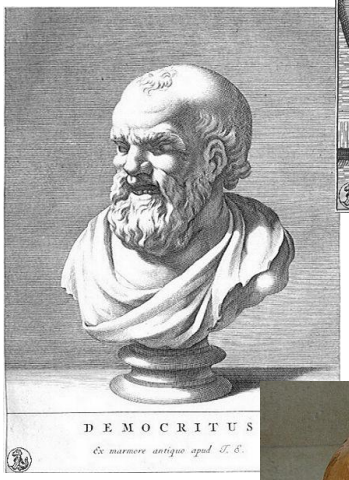
- four entities: air, water, earth and fire
- properties of these entities resulted from the interaction of substances with each other
- this idea was developed by Aristotle (4th century BC)

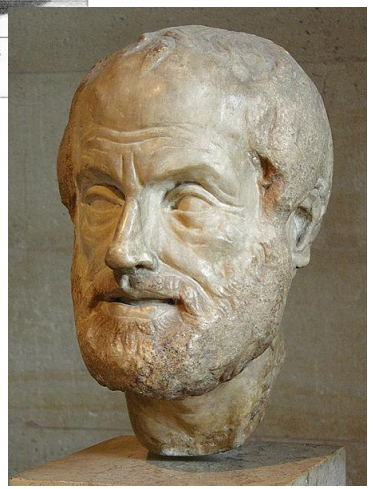
Democritus (4th century BC):

- atomic theory supported on the basis of materialistic
- discontinuity of matter
- this theory has not gained many supporters and then returned in the nineteenth century

Aristotel (4th century BC):

- matter is able to issue a cold, it can be wet and dry - it all adds up to the elements of Empedocles, fire - heat, water - moisture, air - cold; earth - dry





Evolution of chemistry - Ancient and the Middle Ages

The development of chemists practical skills was observed. The method of obtaining metals from ores and glass products were improved. Lime and bricks and were burned also extracting the individual salts was known. Also the manufactured paints, medicines and dyes were produced. Fermentation processes have also been developed.

Also preople created the first encyclopedic work, such as "Natural History" by **Plinius**.

Alchemy has contributed to the development of many experimental techniques (extraction, distillation, crystallization). Also obtained many substances, for example, mineral acids and their salts.

Also the theoretical chemistry had been developed, especially in the Arab world (**Avicenna**, who lived from 980-1037 BC).

Evolution of chemistry – 16th -18th century

At the beginning of 16th century the scientists can be called chemists. **Paracelsus** (1493-1541) - the founder of medical chemistry and discoverer of bismuth and hydrogen

Robert Boyle (1627-1691):

- 1661 "Chemista scepticus" (The skeptical chemist) - first manual of chemistry
- he gave a definition of a chemical element and found that it is a simple, durable material whith is a part of compound
- in 1680 he discovered phosphorus (extracted from the urine)

Georg Ernst Stahl (1659-1734):

- combustion theory - the theory of flogiston
- sme substances are rich in flogiston, such as lead burnt (devoid of flogiston) by heating with coal (coal was kind of a substance rich in flogiston), you can get back lead

Evolution of chemistry – 18th century

Michail Lomonosov (1711-1765):

- refuted the flogiston theory - he concluded that chemistry, as it is a science, must be based on the specific rights
- in his studies was based on the physics and mathematics
- 1760 discovered the law of mass conservation (attributed to Lavoisier-first publication)
- discovered density, solubility, boiling point, refractive index, and the principle of energy conservation of energy
- started a new branch of science - physical chemistry. In the book "The course of true physical chemistry" (1752) gave a definition of physical chemistry:

Physical chemistry is the science that explains the origins of phenomena occurring as a result of chemical operations in the complex substances, with the physics experiences.

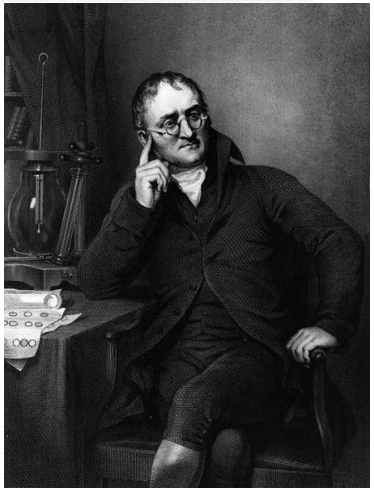
- important role attributed to experiments
- researcher in the field of geology. Also was a poet

Evolution of chemistry – 18th century

Antoine Laurent de Lavoisier (1743-1794):

- started measurements in chemistry , including the weight usage
- erroneously regarded as the discoverer of the of mass conservation law
- proved that all the elements can exist in three states of matter : gaseous, solid, liquid
- showed that during the combustion of materials substances react with oxygen
- oxygen is essential for the production of acids and plays a key role in the breathing of animals and plants and in the process of metal corrosion
- established a quantitative law concerning chemical composition (atom is conncected with mass, which is characteristic for each element)
- discovered that hydrogen is combined with oxygen to form water
- 1789 created a work "*Traité élémentaire de Chimie*" (Elementary Chemistry Issues) is often considered the first modern textbook of chemistry - manual contains a list of the following elements : oxygen, hydrogen , nitrogen , phosphorus, mercury , zinc, and sulfur. The list also included the light and heat that Lavoisier also considered as substances
- was a tax collector and by the revolutionaries was declared as a traitor and guillotined

Evolution of chemistry – 18th century

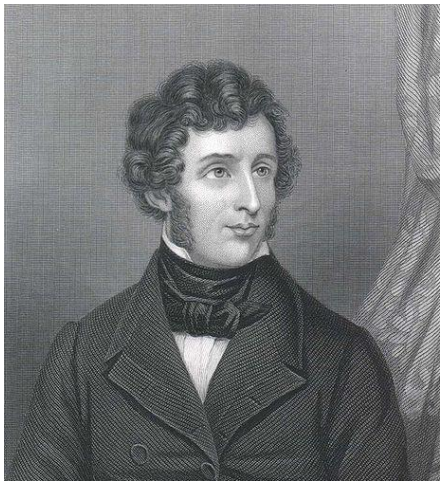


John Dalton (1766-1844):

- creator of the work, "A New System of Chemical Philosophy" saying about modern atomic theory
- first chemist who studied gases - discovered the law of partial pressures
- suffered from daltonism, after this discovery began to explore in detail the disease
- believed that matter is composed of indivisible atoms
- all atoms of one element are identical in mass and other characteristics
- each element is made of unique atoms, differ from other by mass
- atoms are indestructible and are not subject to changes during chemical reactions, only changes their mutual arrangement and relationship
- chemical molecule consists of a finite and limited number of atoms of different elements
- from 1788 wrote daily weather, which included at the end of his life about 200 thousand entries for the county in which he lived
- 1788 began observations of the aurora borealis and believed that there is a relationship between the phenomenon of the aurora and magnetic field
- presented the structure of the passat winds, and was the first who show that rain is caused not by a change in pressure, but the change in temperature with altitude

Evolution of chemistry – 19th century

It has also started to make attempts to classify the known elements (**Dmitri Mendeleev**)



In the 19th century organic chemistry was developed.
Friedrich Wöhler (1800-1882):

- 1828 first synthesized urea and refuted theory that the organic compounds are formed only in living organisms (with the collaboration of unknown never completely „life force”) , but may be formed artificially in the laboratory
- discovered carbide (calcium carbide) and developed a method for the preparation of the acetylene

Catalisys have also been studies
Wilhelm Friedrich Ostwald (1853-1932):

- developed a definition of catalysis (oxidation of ammonia to HNO3), the theory of electrolytic dissociation
- is one of the founders of modern physical chemistry , founded (with van't Hoff) Zeitschrift für physikalische Chemie (1887) and introduced at universities dissertations (today M.Sc.)
- Nobel Prize winner in Chemistry for the year 1909
- supported the idea of an international language (Esperanto , Ido)

Evolution of chemistry – 19th century

Svante August Arrhenius (1859-1927):

- 1887 the theory of electrolytic dissociation (alkali molecules, acids and salts break down into ions in aqueous solutions), which contributed to the development of electrochemistry
- dealt with the properties of toxins and antitoxins, chemical kinetics (eg Arrhenius equation), testing the temperature of the planets and the solar corona and study the aurora borealis
- 1903 Nobel Prize in Chemistry for developing the theory of electrolytic dissociation
- 1907 created the theory of panspermia on the origin of life on Earth (life spreads in space by bacteria moving under the pressure of light)

ıass production of hydrochloric acid, sulfuric acid, nitric acid, soda, chlorine, etc. Steel mills, coke plants were built. On an industrial scale the organics were produced.

Evolution of chemistry – 20th century

The 20th century was a period of very intensive development of chemistry.
Henri Becquerel (1896) – discoverer of radioactivity
Joseph John Thomson (1897) – discoverer of the electron
Niels Henrik David Bohr (1913) i **Ernest Rutherforda** (1911) – discoverer of the planetary model of atomic structure
Maria Skłodowska-Curie i **P. Curie** (1911) – deiscoverers of polonium and radium
Walther Kossel (1916) i **George Craige Lewis** – creators of the theory of chemical bonding **James Chadwick** (1932) – discoverer of the neutron
Werner Heisenberg, Erwin Schrödinger, Wolfgang Pauli (’20 of 20th century) – the creators of the basics of quantum chemistry
Although the discovery radically changed the chemistry all above scientists are well-known as a prominent physicists.

At the end of the 20th century very large changes in the methodology of the study were occured. Common knowledge of chemistry affects culture, and thanks to the achievements of chemistry improved personal hygiene, successfully mastered many diseases, increased access to clothing and footwear, energy, and construction materials. New technologies have enabled the production of materials with new and amazing properties. However, there are also risks. Increased pollution, which leads to the extinction of plant and animal species.

Nobel Prize in Chemistry – since 1980:

2013 - development of multiscale models for complex chemical systems
2012 - studies on protein -coupled receptors G
2011 - discovery of quasicrystals
2010 - Palladium -catalyzed cross-coupling reaction in organic synthesis
2009 - research into the structure and function of the ribosome
2008 - the discovery and development of green fluorescence protein
2007 - study chemical processes on solid surfaces .
2006 - molecular mechanism study of transcription in eukaryotic cells
2005 - studies of the mechanism of olefin metathesis reactions
2004 - discovery of the role of the ubiquitin protein degradation in the body
2003 - the study of channels in cell membranes
2002 - the study of proteins
2001 - work on asymmetric catalysis
2000 - discovery and study of electrically conductive polymers
1999 - research on the transition states of chemical reactions using femtosecond spectroscopy
1998 - development of density functional theory and computational methods in quantum chemistry
1997 - explanation of the mechanism of enzymatic synthesis of (ATP), the discovery of the first enzyme transferring ions
1996 - discovery of a new variety of carbon fullerenes
1995 - the study of reactions in the atmosphere (including the processes of destruction of the ozone layer)
1994 - pioneering studies of carbocations and their role in chemical reactions of hydrocarbons
1993 - methods of site-directed mutagenesis and polymerase chain reaction (PCR)
1992 - contribution to the theory of electron transfer reactions in chemical systems
1991 - contribution to the development of methodology for the High Resolution NMR Spectroscopy
1990 - development of the theory methodology of organic synthesis
1989 - The discovery of catalytic properties of RNA
1988 - determination of the structure of the photosynthetic reaction center of bacteria
1987 - The development and use of particularly selective molecules dependent interactions structure
1986 - pioneering work in the application of infrared chemiluminescence to study the dynamics of chemical reactions , the contribution associated with the dynamics of elementary chemical processes
1985 - a remarkable achievement in the development of direct methods for the determination of the crystal structure
1984 - develop a methodology associated with the chemical synthesis on a solid support
1983 - The work on the reaction mechanism associated with the electron transfer , especially in metal complexes
1982 - development of crystallographic electron microscopy and the determination of the structure of biologically important complexes of proteins with nucleic acids
1981 - theories developed independently from each other, related to the course of chemical reactions
1980 - basic nucleic acid biochemistry studies with particular emphasis on recombinant DNA technology , the contribution associated with the definition of the sequence in the nucleic acids

Physics

Physics is considered to the most developed part of natural science.

Its object is to study the phenomena of the material world (except biological), their nature and the rights of which they are subject. The basic - for the department called **experimental physics** - the way to know and verify these phenomena and laws are observations and experiences, including primarily quantitative measurements to assess phenomena. **Theoretical physics** deals with the analysis and development of mathematical methods of research results, their interpretation and formulation based on them and on the basis of strictly theoretical considerations of general theory. These two sections of physics are closely linked and mutually penetrate.

Early Ionian Greek natural philosophy concerned *physis*, i.e. the nature and hence the name '**physics**'. Originally the subject of physics and philosophy was identified.

Arystoteles was probably the first who distinguished philosophy (*prote filozofia)* as the science of being as being from physics as an empirical reflection of nature.

This difference was fully respected by **Archimedes**, the first great mathematical physics.

Evolution of physics

III-I BC (Hellenistic period).
There were a division of philosophy (invented by Xenocrates) on logic, physics and ethics.

Up to the XVII century
Physics study consisted of all nature (today's phenomenon, which we call physical, chemical, astronomical, meteorological, and all the mineralogy, zoology, botany and science of man).

In the XVIII/XIX centuries
Separated biology from textbooks of physics.

In the XVIII century
There were a division of physics on general physics (*physica generalis*) and the physics of special or particular (*physica specialis physica Particularis*), which were included, among others, issues of chemistry.

In the second half of the XVIII century
Separated chemistry, zoology, botany and mineralogy from textbooks of physics.

Evolution of physics – Antient

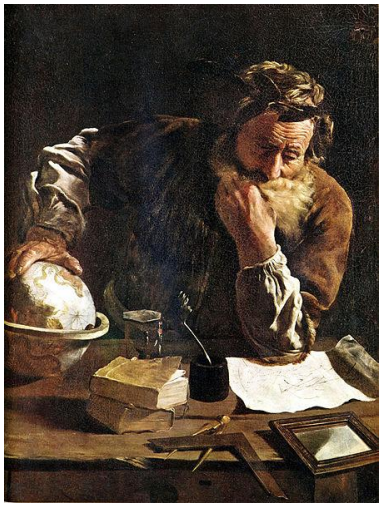
„All the achievements of mathematics, mechanics and astronomy, which converge in the work of Newton, have their origin in Greece” (Van der Waerden, *Science a wakening)*

Aristotle of Stagirus (384-322 BC):
- developed a comprehensive system of knowledge covering all aspects of the world.

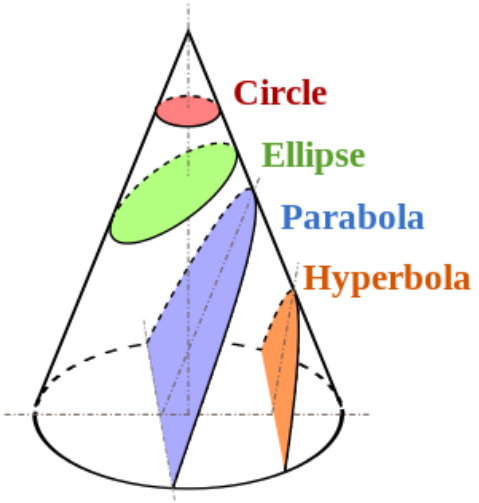
Archimedes of Syracuse (287-212 BC)
- the principle in hydrostatics as Archimedes' principle,
- The lever laws,
- the assignment of the center of mass,
- determination of area and volume.

Apollonius of Perga (262-190 BC)
- Undertook a systematic study of the conic sections.

Claudius Ptolemy (90-168 AD)
- the astronomical treatise now known as the *Almagest*.

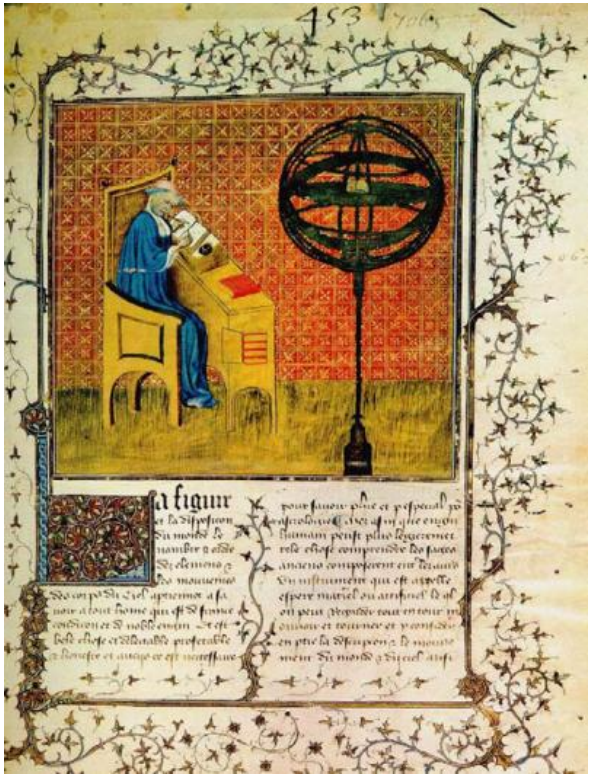


Archimedes of Syracuse



Evolution of physics- Middle Ages

In medieval universities, there were no laboratories and conducted experiments. The subject of research in medieval universities were not natural phenomena, but the lyrics. Freedom of scientific debates in medieval universities contribute to the progress of science.

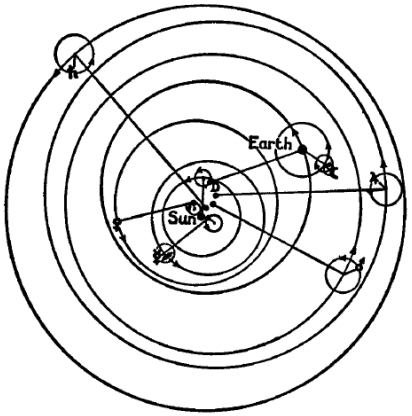


Achievements in medieval mechanics, including :

- the theory of *impetus* (Jean Buridan 1300-1358)
- alternative proposals of dynamics rights (Jan Filopon, Avempace, Thomas Bradwardine);
- beginning of depicting dependence of two variables (Nicole Oresme ok. 1320-1382, Giovannidi Casali);
- theorem speed uniformly accelerated motion (William Heytesbury, Richard Swineshead, Thomas Bradwardine, Nicole Oresme);
- consideration of instantaneous velocity (William Heytesbury, Richard Swineshead);
- acceleration as the intensity of the speed (Nicole Oresme).

Evolution of physics – XVI century

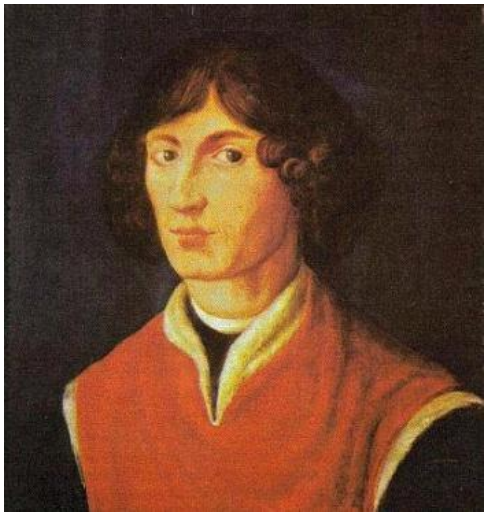
Nicholas Copernicus (1473-1543):



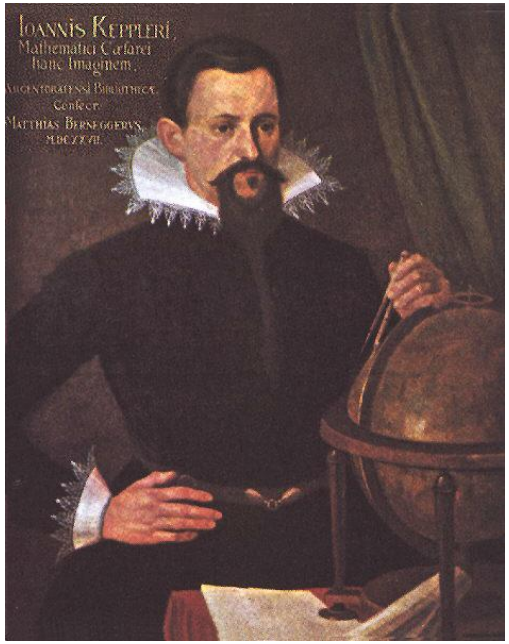
De Revolutionibus Orbium Coelestium
He formulated a heliocentric model of the universe which placed the Sun, rather than the Earth, at the center.

<u>Assumptions:</u>

- There is no one center of all the celestial circles or spheres.
- The center of the earth is not the center of the universe, but only of gravity and of the lunar sphere.
- All the spheres revolve about the sun as their mid-point, and therefore the sun is the center of the universe.
- Whatever motion appears in the firmament arises not from any motion of the firmament, but from the earth's motion. The earth together with its circumjacent elements performs a complete rotation on its fixed poles in a daily motion, while the firmament and highest heaven abide unchanged.
- The apparent retrograde and direct motion of the planets arises not from their motion but from the earth's. The motion of the earth alone, therefore, suffices to explain so many apparent inequalities in the heavens.



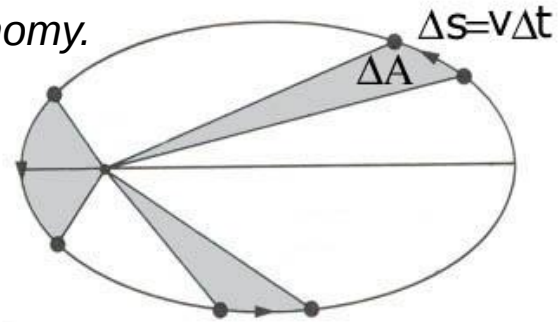
Evolution of physics – XVI-XVII centuries



Johannes Kepler (1571-1630):

„I built my entire astronomy on Copernican hypotheses about the world, on observations of Tycho Brahe finally on the philosophy of the magnetic of William Gilbert”

Astronomia nova,
Harmonices Mundi,
Epitome of Copernican Astronomy.



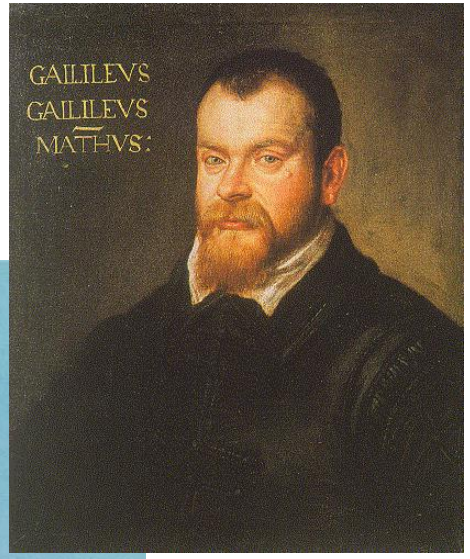
<u>Laws of planetary motion around the Sun:</u>

- The orbit of every planet is an ellipse with the Sun at one of the two foci.
- A line joining a planet and the Sun sweeps out equal areas during equal intervals of time.
- The square of the orbital period of a planet is proportional to the cube of the semi-major axis of its orbit

Evolution of physics – XVI-XVII centuries

Galileo Galilei (1564-1642):

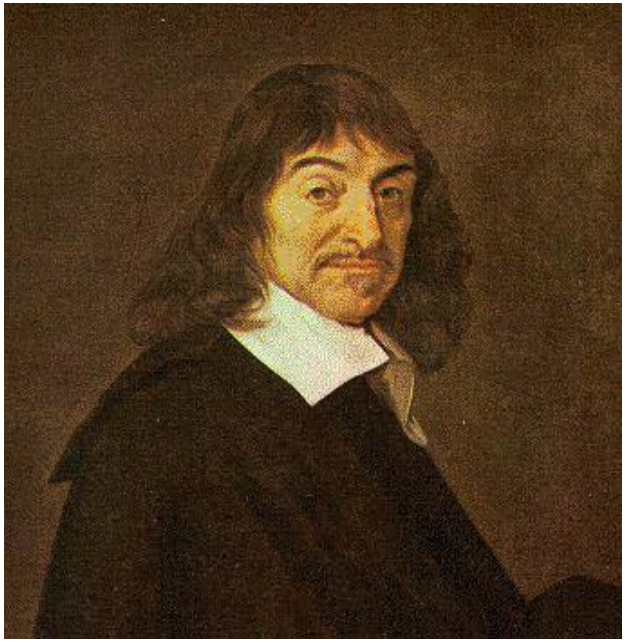
Dialogue Concerning the Two Chief World Systems
He based his views on a large number of experiments and measurements, he discoverer of the universal law of falling bodies and the relationship between force and motion of bodies.



His contributions to observational astronomy include the telescopic confirmation of the phases of Venus, the discovery of the four largest satellites of Jupiter (named the Galilean moons in his honor), and the observation and analysis of sunspots.

Galileo put forward the basic principle of relativity, that the laws of physics are the same in any system that is moving at a constant speed in a straight line, regardless of its particular speed or direction. Hence, there is no absolute motion or absolute rest.

Evolution of physics – XVII centuries



René Descartes (1596-1650)

As a philosopher Descartes was an extreme rationalist.

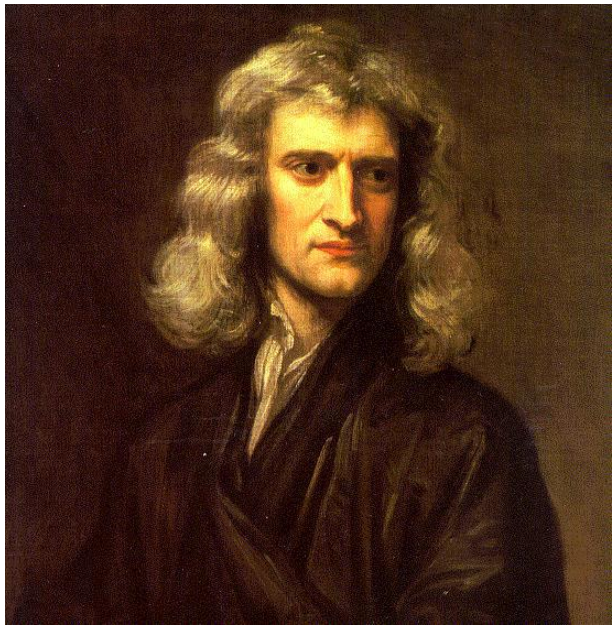
He is perhaps best known for the philosophical statement *Cogito ergo sum* (I think, therefore I am)

Discours de la méthode (Discourse on the Method)

Contributions:

- development of Cartesian or analytic geometry, which uses algebra to describe geometry (Cartesian coordinate system),
- discovered an early form of the law of conservation of mechanical momentum,
- made contributions to the field of optics: the law of refraction.

Evolution of physics – XVII-XVIII centuries



Isaac Newton (1643-1727) :

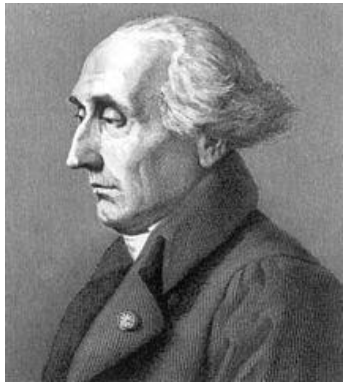
Philosophiae naturalis principia mathematica

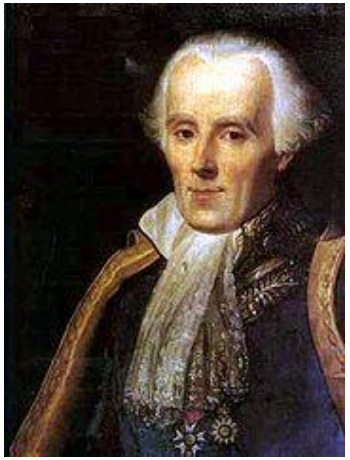
Laws of motion:

- When viewed in an inertial reference frame, an object either is at rest or moves at a constant velocity, unless acted upon by an external force.
- The vector sum of the forces on an object is equal to the total mass of that object multiplied by the acceleration of the object. In more technical terms, the acceleration of a body is directly proportional to, and in the same direction as, the net force acting on the body, and inversely proportional to its mass.
- When one body exerts a force on a second body, the second body simultaneously exerts a force equal in magnitude and opposite in direction to that of the first body.

Evolution of physics – XVIII century

- XVIII c. was a period of great development of theoretical mechanics, mainly because of such scholars as **L. Euler, J.L. Lagrange, J. d'Alembert, P.S. Laplace** and **D. Bernoulli**, who developed a theoretical mechanics of particles and the mechanics of continuous media.
- The eighteenth century was also a period of pioneering experimental work in the field of electrostatics (**Ch. Coulomb**) and electricity (**L. Galvani** and **A. Volta**).





Evolution of physics – XIX century

In the nineteenth century the great successes recorded experimental physics.

<u>The most important discoveries</u>:

- Magnetic field produced by electric current (1820, H.Ch. Oersted);
- Impacts conductors with current (1820, A.M. Ampère);
- Magnetic induction (1831, M. Faraday);
- Electromagnetic waves (1886, H.R. Hertz);
- X-rays (1895, W.C. Roentgen);
- Electron (1896, J.J. Thomson);
- Radioactivity (1896, A.H. Becquerel and basic studies (1898-1910, M. Skłodowska-Curie i P. Curie).

Evolution of physics – XX century

The twentieth century in physics is primarily a period of rapid growth and great success of **physics of the atomic nucleus** and **physics of elementary particle**, as well as the emergence of **solid state physics** and band theory of metals and semiconductors (1930-1940, A.H. Wilson, N.F. Mott, F. Bloch, L. Brillouin), which resulted in the development of quantum electronics and building the transistor (1948) and maser (1954) and laser (1960).

Key discoveries :

- discovery of the atomic nucleus (1911),
- the first artificial nuclear reaction (1919),
- formulation of the proton-neutron theory of the atomic nucleus (1932),
- discovery nuclear fission (1942),
- conducting the first controlled chain reaction (1942),

- discovery of electron diffraction (1927),
- first antiparticle-the positron and neutron (1932),
- first meson (1937-1947),
- confirmation of the existence anti-nucleons (1955-1956),
- quark hypothesis formation (1964).

Nobel Prize in Physics - since 1980

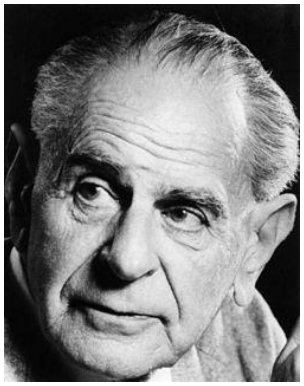
1981 - contribution to the development of laser spectroscopy, and high-resolution electron spectroscopy
1982 - theory for critical phenomena in connection with phase transitions
1983 - theoretical studies of the physical processes of importance to the structure and evolution of the stars; the nuclear reactions of importance in the formation of the chemical elements in the universe
1984 - decisive contributions to the large project, which led to the discovery of the field particles W and Z
1985 - the discovery of the quantized Hall effect
1986 - fundamental work in electron optics, and for the design of the first electron microscope, scanning tunneling microscope
1987 - important break-through in the discovery of superconductivity in ceramic materials
1988 - the neutrino beam method and the demonstration of the doublet structure of the leptons
1989 - of the separated oscillatory fields method and its use in atomic clocks; the development of the ion trap technique
1990 - investigations concerning deep inelastic scattering of electrons on protons and bound neutrons
1991 - liquid crystals
1992 - invention and development of particle detectors, in particular the multiwire proportional chamber
1993 - the discovery of a new type of pulsar, a discovery that has opened up new possibilities for the study of gravitation
1994 - the development of neutron spectroscopy; the development of the neutron diffraction technique
1995 - discovery of the tau lepton; the detection of the neutrino
1996 - discovery of superfluidity in helium-3
1997 - development of methods to cool and trap atoms with laser light
1998 - discovery of a new form of quantum fluid with fractionally charged excitations
1999 - elucidating the quantum structure of electroweak interactions in physics
2000 - developing semiconductor heterostructures used in high-speed- and optoelectronics; invention of the integrated circuit
2001 - achievement of Bose–Einstein condensation in dilute gases of alkali atoms
2002 - contributions to astrophysics, in particular for the detection of cosmic neutrinos; discovery of cosmic X-ray sources
2003 - contributions to the theory of superconductors and superfluids
2004 - the discovery of asymptotic freedom in the theory of the strong interaction
2005 - contribution to the quantum theory of optical coherence; and development of laser-based precision spectroscopy
2006 - discovery of the blackbody form and anisotropy of the cosmic microwave background radiation
2007 - discovery of giant magnetoresistance

The reduction of chemistry to physics

According to the reductionist, chemistry is a special case of physics.
They believe that all areas of chemistry at a fundamental level come down to quantum physics.
Methodologically, this involves bringing the concepts and theories of chemical to concepts and theories of physics.
<u>Proponents of reducing chemistry to physics:</u>

- Wolfgang Pauli
- Steven Weinberg
- Michał Heller
- Karl R. Popper



Chemistry in the context of other disciplines:

Chemistry is divided into a number of sections:

- inorganic
- organic
- analytical
- physical
- supermolecular
- metalorganic
- environmental
- nuclear
- comestible
- of medicines
- judicial
- cosmologic

It connects also with other sciences:

- biochemistry
- geochemistry
- astrochemistry
- physicochemistry
- cosmochemistry
- electrochemistry
- crystallochemistry
- thermochemistry
- radiochemistry

Chemistry in philosophy

Philosophy of science, both in Poland and in the world so far neglected chemistry (focusing primarily on physics. Institutionalized philosophy of chemistry, separated from the philosophy of nature, appeared in the 90s of the twentieth century.

The most serious causes of marginalization chemistry:

- lack of focus on the study of the theory (they lacked in chemistry)
- dominance of the belief that chemistry can be reduced to physics

However, chemistry is an area of exceptional performance:

- paradigmatic science laboratory (in the sense introduced by the philosopher Thomas Kuhn in his book Structure of Scientific Revolutions (1962) - a set of concepts and theories forming the basis of the science, which can not be questioned
- plays a central role in the practice, rather than theorizing
- chemistry laboratory practice is to experimentation, and intervening manipulation, and also the production of new substances having the desired characteristics, most of which do not exist in nature in their natural state
- discipline in which the practical effects significantly changed the face of modern civilization
- has strong links with industry and technology, which modifies still areas of our collective life and the environment

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Eugeniusz Szumakowicz
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Cracow University of Technology Press, Cracow 2004.

Summary

This book is composed of seven chapters presenting various aspects of human existence in the natural and social world. The very broadness of the adopted cognitive horizon implies the need for a philosophical and interdisciplinary approach. Chapter one deals with the relationship between the world conceived from the perspective of physics and/or chemistry and the world of human affairs. The intentional character of the latter is stressed and illustrated using concrete examples from social life and culture. Chapter two enters the domain of organic life, that is nature sensu stricto (as distinct from the physico-geometrical cosmos), and the essential characteristics of the organic structure (in comparison with the mechanical one) are also investigated and formulated. The next two chapters are semiotical in approach. Their aim is to dismantle certain myths and naďve ideas that result from overestimating the possibilities of the sciences (such as the brain and neural sciences) and, on the other hand, to expose certain intrinsic aspects of the functioning of language in society. Chapter five complements the preceding two from the viewpoint of logic applied to real thinking and reasoning, whereas chapter six juxtaposes and compares, methodologically and epistemologically, the two sciences of physics and sociology, especially from the perspective of the applicability of mathematical models and methods. This problem leads inevitably to ontological distinctions between different layers of broadly understood reality. This final issue is developed in the concluding chapter, i.e. chapter seven, where a general philosophical perspective is presented that harmonizes the variety of the worlds in which we live.