History of heat/fire

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THE FIRE/HEAT CONCEPT AND ITS JOURNEY FROM PREHISTORIC TIME INTO THE THIRD MILLENNIUM*

J. Šesták[1]** *and* *R. C. Mackenzie*[2]

[1]Charles University, Faculty of Humanities, Areal ‘u Kří e’ 10, CZ-158000 Prague, and Czech Academy of Sciences, Institute of Physics, Cukrovarnická 10, CZ-16253, Prague, Czech Republic
[2]Macaulay Institute of Soil Science Research, Aberdeen, Scotland, United Kingdom

Abstract

The notion of fire/light/heat/energy is recognized as an integrating element in the pathway of ordering matter and society, and its historical aspects are thoroughly reviewed. Fire is argued to be a philosophical archetype and its role in the early concept of four elements is discussed. The Indian, Arabic and Greek historical bases are mentioned. Alchemy is briefly reviewed as a source of the wider adoption of fire. The era of renaissance and the new age are also included. The message of fire/heat is nowadays focused on the progress of civilization, with the assumption of engines as information transducers based on the conscious exploitation of fire. The role of chaos is emphasized. Overall, a condensed but consistent view is given of the various concepts that emerged during the historical progress of the understanding of heat (noting 61 references).

Keywords: alchemy, caloricum, chaos, elements, engines as information transducers, entropy, fire, heat, history, information, living cells, philosophy, thermodynamics

Fire as a philosophical archetype

Motto: ‘Fire shall try every man’s work’ [Corinth. III:13]

The integrative notion of fire/light/heat (and more recently energy) is generally recognized as an integrating element rudimentary in the pathway of ordering matter and society. Its first rendition, called fire, has had an extremely long history, passing through several unequal stages in the progress of civilization. Within the chronicle of the interactions of society with fire, we can distinguish roughly four periods. Perhaps the longest age can be named the period without fire, as the first human beings were afraid of fire (like wild animals), but gradually associated with it a sensation of warmth and cold. Another long era was accompanied by the growth of the continuous

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** E-mail: sestak@fzu.cz

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experience of using fire, which helped distinguish human beings from animals (the use of fire as a weapon, as a conscious source of warmth, or as a substantial aid in cooking meat, making it more easily digestible). A definite advance came with the recent, but short period of making fire, up to the present brief exploitation of fire, including the domestication of fire and its use as energy.

Fire is believed to have both heavenly and earthly origins: it is brought from the sky by lightning, and it lives in the underworld of volcanoes, so that the worship of fire is widespread, particularly in areas where the older earthly fire is believed to be the image of heavenly fire. For various psychological reasons, fire is considered to be a personified, animated or living power: it is red like human blood, and warm like the human body, it shines brightly in the night and may have a form of 'eternal life', or by constant rekindling can be made into a 'perceptual fire'. Masculine fire (the principle Jang – light) is thought to fight from the center and to have the power to decompose what nature has joined together, while feminine fire (the principle Jin – shadow) attacks from the surface, is difficult to restrain and often disappears as smoke. Fire was believed to extend throughout the celestial spheres, and even time was thought to move in cycles (ekpyrosis, 'conflagratio'), involving a period of its destruction by fire during the cycle's involution and/or end. Fire has for all intents and purposes accompanied mankind's thoughts, beliefs and doings from the very beginning [1–38] until today's serious scientific treatises [39–57], including the theory of chaos applied, for example, in the transfer and/or distribution of heat (weather).

The generation of fire, which would have been unachievable without the aid of fire bores or saws, was sometimes also perceived as a sexual act, with the imaginative

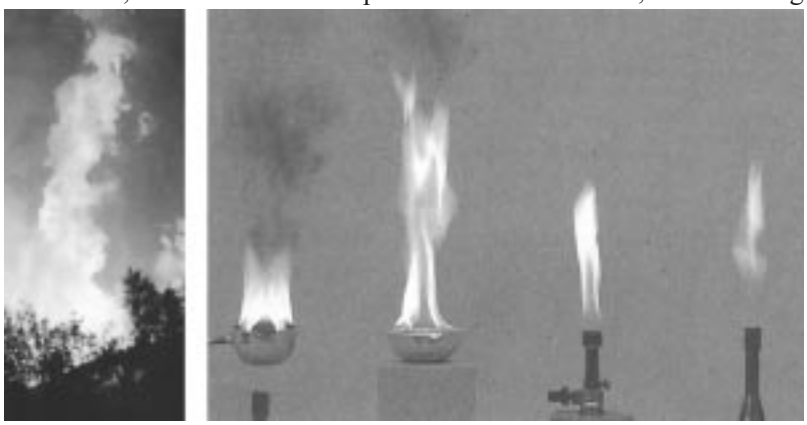

Fig. 1 Fire has created a landscape diversity through regular lightning and burns. Thanks to the fire, the landscape mosaic has been maintained and, on the other hand, thanks to the mosaic structure, the extent of the fire damage has been kept local. This natural course, however, has been disturbed by man-made woods – monotonous cultivation (agriculture) (left).
The shape of flame is similar for the substrates of natural and artificial fires. Burning natural oil has a similar character to the natural burning of woods. The lower the content of carbon, the lighter the flame (throughout the sequence from oil, to gasoline, butane and methane) (right)

concept of male and female firewood. Corresponding views were probably most pronounced among Aborigines, and such a conceptual framework consequently influenced the ideas on fire in the body of humans, especially of women, as a center of sexual life. In archaic civilizations with sacral kings, the sacred perpetual fire (state fire) of the residence and temples of the royal ancestors was believed to have a phallic element. It was sacred for virgins, who were viewed as wives of the fire. The extinguished and rekindling of fire at the inauguration of a prince points to the idea of a spirit of the princes within the state fire and also to the cyclical renewal of the state in the purifying act of fire, which signifies the beginning of a new era. According to some Hermetic and Gnostic doctrines, it was believed in the mysteries that the soul emanated from the Lord, fell into the body, casting its internal fire, and then had to return to its former home. Thus, it was believed that during cremation the soul is helped to separate from the body though the effect of external fire. Fire has therefore become a mandatory part of almost all holy places.

Burning, as a source of fire, is invisible, perceptible in its product only, i.e. flame, which exhibits a surprising similarity for different substrates (fuels) and is scientifically reasoned to be a universal portrayal of conglomerated chemical reactions resulting in energy production in the form of heat and light (Fig. 1). At the beginning of science, however, flame was acclaimed as an optical illusion and only a spectre, as fire was felt not to have a substantial carrier: it illuminates and animates its surroundings, making the illusion of liveliness. Fire also calls for a vision of a living organism (‘agile’ sive/i.e. ‘ignis’) exhibiting growth and change, digesting and shining, or a need for food and air. Fire is composed of very sophisticated internal structures of flames, and shows continual instability, self-structuring and self-reproduction. It is often exemplified by a burning candle: the more the wick flames, the more it is extinguished, being buried in the melted wax, thereby feeding back the actual fuel supply. Flame is the visible pattern of fire and has been treated in many scientific, poetical and mystical essays [23–28]. There is a Latin proverb ‘Ignis mutat res’ (fire changes things), stating that through fire all matter changes its properties, metals become ductile, or raw food-stuffs change into a meal. Fire furnishes heat and light, which are symbols of the intimate asylum of safety guarded homes, but at the same time is a source of perpetual danger: the domestic fireplace (‘focus’) can become a focus of complete destruction. Fire is part of ‘apeira’ – limitless, sacred and self-referenced ‘apeiron’ (primordial beginning – subsistence). Fire (‘pyr’ – flamma) delivers light (~eyesight), which is transmitted (~heating) by air (‘aer’ – flatus), reflected (~appetite) by water (‘hydro’ – fluctus) and absorbed (~tactility) by earth (‘ge’ – moles). Fire is the source of both expansion and contraction, annihilation and purification: the light of ideas reveals the truth, while the glow of fire proves its genuineness. Everything that flares up ends in ashes. Fire is self-destructing, factually turning itself into a worthless thing. Fire is a fundamental beginning, with its final effect being the entire end. Fire is often assumed to be a mirror of chaos.

Mission of fire – creative imaginations

It is a part of mythology that Prometheus stole fire from Zeus (thought by platonians to have actually happened to the blacksmith Hephaestus). It is of interest that the word 'promethean' is derived from the Sanskrit name for a drill, and can thus be understood as a personification of the act of making fire. Oastanes (about 500 BC), teacher of Democritos, was aware that there existed a natural power (possibly fire in the sense of energy) that can overcome all other powers, and is therefore capable of creating unification, but is also ready repeatedly to diminish it. However, this was not specified until speculations by some early Greek philosophers, notably Empedocles (500 BC), who was apparently the first to name the four basic elements (Fig. 2) that signified the substantially from which all subsistence/being was composed. In Greek, however, the elements are termed 'stoicheia' (today's chemical stoichiometry) and the overall name 'elementa' (beginning) was authentically derived from LMN, the first letters of the Etruscan (Phoenician alphabet). Empedocle's concept of four such patterns/roots ('rhizómata') was made were widely known by Aristotle 70 years later, but this came together with the fifth platonian subsistence/being 'quinta essencia', which was thought to interject a certain qualitative principle ('arche'). It was correspondingly conceived as ether ('aither') – something celestial and indestructible (derived from 'aitho', meaning glowing, flickering), possibly related to the Aristotelian 'primeval matter' ('prote hyle') and interpreted as the presence of subjects/things. Four elements had gradually been proposed through the ideas of Anaximenes (air), Xenophanes and Parmenides (earth) and Heracleitos (fire) and the latter also emphasized that fire most completely reveals the 'heavenly' reality of our universe, i.e. its order ('kosmos'). Sanctified fire gave the basis of the 'Empedocles complex', where the love of fire is linked with its respect and the instinct of life with the perception of death.

Fig. 2 Early concept of material elements (left). The clockwise solid line denotes creation, while the dashed lines with arrows symbolize destruction. It is noteworthy that this scheme already accounted for creation (water-wood) and destruction (fire-wood) of life. In the middle, a loop consisting of two dragons is revealed, together with the symbols of four elements in the corners. The upper dragon has wings, to symbolize volatility, while the lower dragon has only legs, to denote a solid. The dragon and fish are exchangeable (right) and from two fishes biting each other's tails the symbol of jin-jang is created, which has had an important role in Chinese alchemy and philosophy

In such a Greek interpretation, it was supposed that all material things were different combinations of elementary fire, air, water and earth with the integrative and structural essence ether, which was a heavenly natural and imperishable matter, thought to make up the universe of the fixed stars and the firmament. The four elements were not only plain mixtures (quantities), but also the bases of newly unified matter, whose balance was retained by four qualities: hotness, coldness, humidity and dryness, each element being defined by pairs of opposites (dry/hot, dry/wet, wet/cold and dry/cold). Hotness and coldness were active, whereas the remaining two were passive qualities. Properties associated with dominant (active) qualities have a tendency to grow if the object is surrounded by either a hot or a cold environment. In fact, this was the first definition of a thermal process. The source of hotness was anticipated (underworld hell), but the source of coldness (primum frigidum/colidum) was never identified.

Certainly, matter ('materia' – potentia pura) was not distinguished from energy ('energeia' – actus), so that heating a metal involved simply adding more 'fire' to it. Theophrastus [11] (287 BC) proposed three stages of fire: glow, flame and light, while Galenos (129–199 AD) introduced the idea of four degrees for becoming warm or cold with the 'neutral point' of equal parts of ice and boiling water. These four degrees were still accepted by medieval alchemists, and Mylius (1622) [6] proposed classification according to the Sun passing through Aries (signifying calcination), Cancer (solution), Libra (sublimation) and Capricornus (fermentation). The highest degree of fire was burning as vehement as fusion and each degree was twice as great as the preceding degree. The Bohemian educational reformer and Czech thinker Comenius (1592–1670) progressed to distinguish three degrees of heat (calor, fervor and ardour) and cold (frigus, algor and an unnamed degree) with a reference to a normal temperature (tepor). The highest thermal stage 'ardor' meant an internal degradation into 'atoms'. He stated [19] an almost modern definition of thermal analysis (skillfully interpreted by Mackenzie in [33]) '…to observe clearly the effects of heat and cold, let us take a visible subject and let us observe the changes that occur while it is heated or cooled, so that the effects of heat and cold are apparent to our senses…'. Comenius was also the first to observe the 'non-equilibrium character' of such thermal treatment and analysis '…with a well burning fire we can melt ice to water and heat it quickly to very hot water, but there is no means of converting hot water to ice quickly enough, even when it is exposed to very intense frost…', intuitively thereby noting the phenomena of latent heat and also undercooling.

Alchemy as the basis for adopting fire

The history of fire cannot be complete without mention of the spheres of alchemy [17–22, 27]. The origin of the word involves several associations: from the Arabic 'Al chama' (treated by fire) through the Hebrew 'Ki mijah' (given by God) to the Greek word 'chemeia', found in the writing of Diocletian as the art of making metal ingots, or 'chumeia' as the art of extracting juices or herbal tinctures. Even the abbreviation INRI 'Jesus Nazarenus Rex Judaeorum') was once interpreted as 'Igne Natura

Renovatur Integra', i.e. through fire Nature is restored to its wholeness. Alchemy, however, was subdivided into spagyrii, the art of producing medicaments (Table 1), dyes, ceramics, etc. (often in attempts to transform matter into algebraic combinations), archemii, focused on the development of metallurgy and the transmutation of metals, and Hermetic philosophy (often synonymous with alchemy overall, Fig. 3), i.e. sanctuary learning ('prisca theologia'), built up on performance ('traductio'), explanation ('exegesis') and interpretation ('hermeneusis' – nowadays giving a substructure for a modern interpretative hermeneutic description).

Table 1 Scheme of spagyric treatment of herbs (possible early roots of homeopathy)

Harvesting plants under given conditions (at full moon – polarized light, etc.)			
Distillation ('separatio')			
Separation of etheric oils ('sulfur')			Fermentation ('purificatio')
Separation, filtration			
Distillation		Calcination of plant residue	
Alcohol dissolution	Calcination of sediment ('calcinatio')	Plant ash ('sal')	
Distillation	Residual ash		
Absolute alcohol	Agglomeration ('cohobatio')		
	Filtration		
	Spagyric tincture		

Fig. 3 Allegoric pictures associated with edition of books relating to Hermetic philosophy and alchemy. The latter discloses the position of alchemy as a figure sitting on royalty, whose head touches the sky, while the left hand holds a scepter as a symbol of power, and the right hand one open and one closed book, representing the open and secret sides of science. The ladder symbolizes the patience necessary to achieve all steps of a great masterpiece

It was aimed at providing trust in the existence of the 'first mover', God, as it reflected the evident order of the world. This argument, first formulated by the Persian prophet Zoroaster, was expressed in the form of questions: Who could have created the heavens and starts? Who could have made the four elements, except God? Hermetic learning was primarily ascribed to astrology by the Hermes Trismegistos, but later extended to medicine and alchemy, where the Byzantine 'Tabula Smaragdina' became a favorite source even for medieval alchemists. It contained seven principles, and scholars achieved knowledge of the laws of sympathy and antipathy, by which the parts of the universe were related. Hermetism was extensively cultivated by the Arabs, and through them it later reached and consequently greatly influenced Western culture, though it was often misinterpreted. Hermes' stick 'rhabdos' was ornamented with two twisted snakes showing 'waving water and blazing fire' as a unity of contradictions, thus becoming a symbol of life. In present times, it may also resemble the double helix of the DNA structure.

Alchemy most probably originated in China (known as early as 600 BC) in connection with an enterprise older than metallurgy, medicine, and in the belief that physical immortality could be achieved through drugs. Alchemy probably vanished when the Chinese adopted Buddhism, which offered other, less dangerous avenues to immortality, via meditation. In India too, alchemy came to be associated with the rise of Tantric religious mysticism, leaving a record in the writings 'Rasarnava' (AD 1100 – Treatise on Metallic Preparations). The earliest records, from 500–300 BC, already pointed out that the theory of nature was based on the conception of material elements (fire, wind, water, wood, metal, earth and space, cf. Fig. 2), vitalism ('animated atoms') and the dualism of love and hate or action and reaction. In the Theravada view, there was a plurality of the universe, surrounded by water and mountains, having three planes of material form (physical body) and of immateriality and/or formlessness (body of law).

The Indians exploited metal reactions more widely and knew as many as seven metals (and already subdivided five sorts of gold). They supposed that metals could be 'killed' (corroded) often to provide medicine bases, but not 'resurrected', as was customary in later European alchemy. However, the known alchemy tradition points to Egypt as its birthplace, and the Greek God Hermes (identified with the Egyptian god Thoth) is represented as the father of alchemy, first noted in 150 BC, in the Emerald Tablet (part of a larger book of the secrets of creation), which existed in both Latin and Arabic manuscripts. The history of Western alchemy may go back to the beginnings of the Hellenistic period, starting around 300 BC, and represented by Zosimos of Panopolis, who expressed alchemical theory and focused on the idea of a substance 'tincture' that was capable of bringing about an instantaneous and magical transformation. The earliest notable author was designated by scholars as Bolos of Mende, a Hellenized Egyptian, author of a treatise called Physica et mystica (Natural and Mystical Things), containing obscurely written recipes for dyeing and coloring, as well as gold an silver making.

Inherited concept of fire within the idea of four elements

As mentioned above, the Greek philosophers played the most important role. The Greek word philosophy, meaning love 'philein' and wisdom 'sophia', first appeared in the 5th century BC and was primarily concerned with the problem of 'the One and the Many'. Simply stated, it involved the explanation of the infinity of things in the universe (the Many) and the early Greeks believed that the single unifying thing (the One) was some material substance, such as water or stone. They were concerned with finding the unchanging principle of substances that lay behind all changes, and the stable unchanging component of the universe the Greeks called 'arche' and living nature 'physis'.

Plato (427–347 BC) seemed to distinguish between fire and heat, while Aristotle (383–322 BC) apparently differentiated temperature from a quantity similar to heat, even though the same word ('thermon') was used for both. Aristotle and later philosophers paid attention to the notions 'spirit' and 'breath', which by some were identified with ether, and by others with entire fire, which was always regarded as a basic composition element. Democritos (460–370 BC) and his teacher Leucippos already assumed its dependence on the shape and arrangements of elementary particles (atoms). Democritos also supposed that the soul had a fire nature. The Pythagoreans distinguished notions for matter and form, linked through a process of development. In contrast with Plato, Aristotle believed that form had no separate existence, but was immanent in matter – their philosophy and science ideas dominated Western thoughts for two thousand years until a radical change was brought about by the new discoveries in physics, astronomy and mathematics (Copernicus, Bruno, Galilee, Descartes, Bacon and Newton), with the world assumed to be a perfect machine governed by exact mathematics.

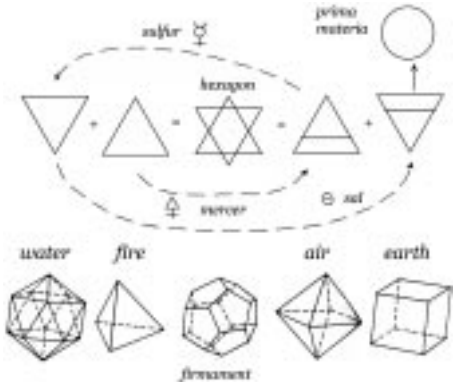

Fig. 4 Symbols used for depiction in the concept of four elements

The oldest book on chemistry was known as the 'summit of perfection' [2], where the terms alcohol, alkali, borax and elixir were already used, but it also held that metals were compound bodies made up of mixtures of mercury and sulfur only. 'Prima materia' (first matter) was recognized as being fixative (visible solid-earth,

represented by sulphur), quintessential (personification – sal) and evanescentive (implicit, hidden – air, represented by mercury). It was characterized by triangles pointing up (escaping) or down (falling) (Fig. 4). It was close to the platonian geometrization, representing fire as a tetrahedron, air as an octahedron, water as an icosahedron and earth as a hexahedron (cf. the illustrations in the lower line of Fig. 4). By analogy, it showed spheres of Mars, Earth, Venus and Mercury, with the Sun in the center. Reciprocation of the elements with the geometrical bodies, however, led to the mechanization and geometrization [29] of learning, and the dodecahedron was assumed to act as the fundamental structure of the firmament. Mere abstraction of four elements was not thought to be enough for the needs of the teaching, of alchemy, so that three other imaginary principles were also included, Table 2.

Table 2 Initiative of 'Tria Principia', derived from the scheme of four elements and their consequent performance: fire acting upon air created 'sulfur', air against water released 'mercer' and water against earth gave rise to 'sal'

combustibility	fusibility, ductility	durability
sulfur	mercury	salt
soul, psyche ('mens')	mind, brain ('anima')	body, figure ('soma')
Egyptian tradition	Greek philosophy	Metallurgy spirit
	Emphasizing priciple of	
– flammability	– shining and volatility	– solubility/incombustibility
	Taste of	
– smearingness, oil	– alcohol	– salt, earthiness
hidden air, water	air, fire	earth

In the Middle Ages, European alchemy was chiefly practised by Spanish and English monks (R. Bacon, who seemingly invented fire powder, and Lullus) seeking to discover a substance more perfect than gold (philosopher's stone) and a potable gold (elixir of life). It is noteworthy that the Swiss/German Paracelsus (1493–1541) held that the elements of compound bodies were salt, mercury and sulfur, representing earth, water and air, respectively. Fire was regarded as imponderable or non-material, and alchemists used heat lavishly; most of their illustrations include some indication of fire, a furnace or a symbol of sulfur. Despite the crudity of the above-mentioned degrees of heat, alchemists laid more emphasis on an accurate temperature control of furnaces (Norton [4]), necessary in early metallurgy (Agricola [5]). The adjustment of temperature was purely manual, however, including oil lamps with adjustable wicks, water and sand baths for lower temperatures and variation of fuels for higher temperatures. In various forms of processing, such as the firing of ceramics or the melting of glass, it was vital to keep certain temperatures constant. This required the introduction of early scales for experimental practice. Moreover, fuels giving moist and dry heats were distinguished, with an awareness of how to produce high temperatures (also by using burning glasses and mirrors). A vast store of knowledge was accumulated of the effects of heat on various substances, even if it was not

possible to interpret the results and satisfactorily measure the temperature. An undiscovered element, termed alkahest ('alkali est') in the sense of a universal solvent (resembling today's action of catalysts), was believed to exist common to all (of which the four basic elements of ancients were merely derivative forms), to prove to be a universal medicine. Alchemy flourished markedly in the territory of the Bohemian emperor Rudolf the Second (1552–1612) and Prague became home to many famous alchemists, among others Hajek or Rodovsky of Czech origin, and the noteworthy Stolcius (1600–1660), who wrote an advanced book [3], noting the laws of light refraction and the nature of the laws of conservation. He was to introduce at the Bohemian Charles University (founded in Prague in 1348) the first specialization called 'chimiatrie' a novelty as concerns the traditional university disciplines 'artes liberales' and 'artes mechanicae'.

The Renaissance and the New Age

In the 'Sceptical Chymist' (1661), Boyle (1627–1691) attacked the theory of four elements, and his explanation of an element in the sense of its apparent 'non-existence' provided the modern roots for the natural sciences and the definition of a modern concept of the chemical elements. It is worth noting that Plato possessed a similar view, based on the 'chóra' (analogous to the Indian 'amah', understood to become fire or water containing 'proté hylé'), i.e., the continuous dynamic transformation of elements within themselves (resembling the quantum vacuum in the framework of bootstrap and/or particle democracy). The four elements were then identified with macroscopic phases of a gas (from the Dutch contortion of the Greek word 'chaos') and the Latin-derived liquid and solid. Fire became heat and was recently related to plasma; accentuation of this and further thoughts of yet other forms of energy (e.g. nuclear) lie outside the scope of this article. Although the 17th century was a time of notable scientific progress [30–38] (notwithstanding the reminiscence of Greek philosophy) scientists themselves were then still far from the respected scientists of the current era (Fig. 5). Some of them, held to be responsible for the introduction of modern theories, such as Newton (1645–1727) and Leibniz (1646–1748), were still devoted alchemists. The idea of 'fire fluid' (globular particles which attach easily only to combustible objects) persisted for another two hundred years, with the assumption that, when a substance was burnt, the non-substantial phlogiston ('terra pinguis') escaped. The definitions of the laws of conservation needed more precision on account of the action of elderly traditional vital and mortal forces, conservation being assumed to be something general between and within the system, probably first discovered by the non-cited Czech Marcus Marci (1596–1667) [8]. An important role was played by Descartes (1596–1650) [7], though he first believed that the Universe was filled with matter in three forms: fire (the Sun), transparent matter (the Heavens) and dark matter (the Earth).

Until the work of the Scot Black (1728–1799), the notions of heat and temperature (temper/temperament, first used by Avicena in the 11th century) were not distinguished. He and Magellan (1722–1799) made known the quantity that caused the

change of temperature, but itself is not temperature (the concepts of latent heat and heat capacity, explaining how heat is absorbed without changing temperature and what heat is needed to increase a body's temperature by one unit). A noteworthy feature is the original proposal of a heat unit expressed in therm (to warm 1 g of water), which was proposed by Groffith to be named after the physicist Rowland (1848–1901). Yet, at the beginning of 18th century, Boerhaave (1668–1738) [10] warned that '…if we make a mistake in the interpretation of what fire is, this deficiency can afflict all disciplines of physics and chemistry, because in all natural creations fire is involved, in gold as well as in emptiness…'. Rumford (1753–1814) still presented qualitative arguments for the fluid theory of heat, but succeeded in evaluating the mechanical equivalent of heat; this was not accepted until approved by Mayer (1814–1878) and particularly by Joule (1818–1889) for the transformation of electrical work.

Fig. 5 Examples of illustrations from old writings: Left – The triangle symbolizes both earth and fire (with its corner pointing up). It may be read in such a way that water and earth would be freed by fire form prima materia and transformed to 'kvintesency' symbolized by a circle (about 14th century). Middle – Demonic hermaphroid standing on a dragon (symbolizing 'prima materia'). The masculine part holds a sword (justice), and the feminine part a crown (boast), about 15th century. (It is interesting that this was supposed to be part of a gift of the Franciscans to the emperor Zikmund on the occasion of the Constancy council that condemned the Bohemian priest and Czech reformatory speaker Hus to the stake). Right – the geometrical model of the universe, with the outermost sphere of Saturn and with Mercury and the Sun at the center (according to Keppler's Mysterium Cosmographicum, about 17th century)

However, it took two centuries to replace the fluid theory of heat (caloricum, thermogen) by the vibrational view (the state of inherent particles) that was substantiated by Cavendish's discovery of 'inflammable air' (hydrogen) and the theory of combustion by Lavoisier (1743–1794), though he first associated oxygen with phlogiston. Sadi Carnot (1796–1832) provided the theory of a four-cycle device [13] to run an idealized heat engine, proposed on the confused basis of heat transport taking place in the form of a fluid discharging from a state of higher to one of lower ten-

sion (conservation of materialistic caloricum) and supported by Clapeyron (1799–1864). It was notable that Carnot excluded the existence of a thermal perpetuum mobile, formulating an important efficiency theorem: '…the moving force of fire does not depend on the medium used for its outgrowth; its magnitude depends only on the temperatures of the bodies between which the transfer of heat is conveyed…'.

Following the textbook by Pencelet (1826), in 1853 Rankine introduced the term energy – actuality ('ergon' – actus and 'energeia' – activity, in the opposite sense to the possibility 'dynamis' – potentia). Simultaneously with the development of the separated fields of electricity and magnetism, another important field of thermal sciences was introduced, named thermodynamics ('thermos' heat, and 'dynamis' – force). This was first made known by William Thompson (1824–1904), but was preceded by Maxwell's concept of thermal equilibrium [15]. During the 19th century, Helmholtz and Laplace [14–17] described both theories of heat as equally suitable for complying with a theory of temperature measurements, because this was determined only by the state of the system under investigation. A similar understanding was anticipated for the internal motion of particles because heat was also a measure of the transfer of motion from one system to another (kinetic and potential energies being qualitatively different forms of motion, particularly in the scaling variance in the degree of self-organization). Heat transfer is nowadays associated with a modern description in terms of non-integral dimensions called fractals [52–54].

The current message of fire/heat

Motto: 'Ordered by number and by weight of every one' [Ezra 8:34]

The modern scientific world is far from using mystic concepts and nature research is a public property. Early mystical philosophy did not really need exact science. It did not look for mere measurable quantities and scholarly knowledge was therefore deliberately kept a secret, often for moral reasons. The human mind, however, needs a little of both. Hermetic philosophy admitted that the universe is calculable, separating quality and quantity at the same time, i.e. harmony is best perceptible sensually, but also expressible by numbers. Measurement was thought to be associated with the consciousness of the person who actually makes it, but has nowadays come close to the ideas of quantum mechanics. Bohr stated that 'There does not exist a quantitative world. There exists an abstract description of quantum physics. The task of physics is a search not for what nature is, but for what we can say about nature'.

The orderly employment of fire provides warmth and pleasant conditions to think, e.g. about how to order things or how to gain energy with ease. Wild fire destroys everything, creating chaos in both aspects: the material possessions of society and the useful thinking of the mind. Fire leaves a fingerprint in all types of evolution. We may mention alchemy, as an old endeavor for fire/heat. Within the modern world of science, alchemy, as a rather extraordinary field of learning, would surely be subjected to ironical comments. However, we should recall that alchemical philosophy

was close to the science of causation, trying to perfect matter while being aware of nature as the model itself, respecting the order of nature, somehow resembling present-day thoughts about liveable nature (ecology). Alchemy was related with the process of self-recognition, and success in the laboratory led to individualization and *vice versa* (individuality guided the laboratory mastery). Alchemy was a universal art of vital chemistry, which, by fermenting the human spirit, purifies and finally dissolves itself so as to become a kind of philosophy. On the other hand, chemistry as a consequently derived true science of facts, is primarily oriented to the utilization of nature, freely processing and exploiting basic/raw materials and trying to dominate nature – it is shamelessly enforcing order on nature and is neglecting its consequences.

Heat/fire has always played a significant role as an explicit tool, either in the form of industrialized power (applied by men long ago for working materials in the process of manufacturing goods) or as an instrumental reagent (for the modern analysis of the properties of materials). The consequences of a better understanding of heat led to the formulation of a consistent science of thermal physics, and the development of the field of thermodynamics [13–16, 40–42, 55, 56] (and the related domain of thermal analysis, touching on any adjacent field of science where temperature is taken into account). As mentioned above, it was originally developed on the erroneous premises of caloricum, although we should rather say that it was the application of different premises as regards the manner of the individual approach. The fluid hypothesis was common to the way of thinking of Archimedes and the Epicureans, and even to the present-day theories of Prigogine. Our everyday use of the heat flow equations applied in thermal analysis bears the 'caloricum' philosophy. The thermodynamic story is further complicated by the introduction of an artificial quantity called entropy, which eliminates heat from its mathematical framework. The first law of thermodynamics actually gives a quotation of the law of energy conservation, but only under specific conditions for heat that are not fully equivalent with other kinds of energy [35]. Heat cannot be converted back to mechanical energy without changes necessarily affiliating heat with entropy via the second law of thermodynamics, intuitively stating that heat cannot be annihilated in any real physical process. It may somehow be felt that thermodynamics was originally situated on a level of esoteric ('those within') doctrine [35]. (This article purposefully ignores modern aspects of the equivalency of matter and energy and associated spheres of heat/energy exploitation.)

Let us look at the term entropy, after Greek 'tropos' ('trepó' – turn), meaning transformation (proposed by Clausius on analogy with the term energy). Entropy is a measure of the order of chaos, both in physics and in everyday life (e.g. how effortlessly a laboratory can become a mess, and how difficult it is to force everything back to order, humorously illustrating the irreversibility of entropy). In fact, we can never know where an electron is positioned in the atom and the sub-particles quarks are still just 'strange'. Religions, on the other hand, seems to manage ideally to emanate desirable order, with the Bible and moral rules, with everything in its right place. Similarly, we can elucidate symmetry by looking at the thoughts of the Eastern religions

(of the Buddhists, Taoists and Hindus) and their philosophical views of the Universe, comparing these views with the actual scientific facts of crystallography or quantum mechanics, for instance.

The general meaning of chaos is empty space or matter not yet formed (Theogony, about 700 BC). It was derived from the Greek words 'chaskó' (drifting apart, opening) and 'chasma' (abyss, chasm, gap) and was associated with the primeval state of the Universe (also associated with 'apeiron'). In the Chinese tradition, chaos was apprehended as homogenous space preceding the constitution of directions/orientation (i.e. the separation of four horizons) in the sense of a great creation. In Egyptian cosmology, chaos ('nun') represented not only the state preceding the great creation, but also the present state of a coexistence with the world of forms/structure, which also serves as a limitless reservoir of field forces where forms dissolve during infinitesimal time. In alchemy, chaos was associated with primeval matter ('nigreden') capable of creating a 'great masterpiece'. Chaos was a symbolic representation of the internal state of alchemists, who first needed to overcome their unconsciousness to become ready for transmutation study. In Genesis, chaos is understood as a symbol of paltriness and non-distinctiveness, but also a source of feasibility. The word chaos is sometimes taken to mean the opposite of 'kosmos', this latter term having the connotation of order, and the Arabic meaning of 'chajot1 is also closely associated with life. In the Epicurean conception, chaos was a source of progressive transformation. Chaos thus became a definite domain of present-day science, showing by law that disorder can disclose windows of order (order through fluctuations) and that, *vice versa,* order bears inherent minutiae of disorder (disorder as information noise). The theory of chaos provided the bases for various progressive specialties of numerous branches of knowledge [46–51], seemingly important for any further advancement of science in the coming century.

Let us emphasize the first conscious exploitation of fire as proposed by Newcomen (1705), Watt (1800) and Stephenson (1813), while constructing a steam heat engine and later a functional locomotive that actually interconnected the three forms of the above-discussed early elements: heating water by fire to obtain a thick air (steam) capable of providing useful work (moving a piston and turning a wheel). Lenoir (1868, the gas engine) and particularly Otto (1878) and Diesel (1892), who imprisoned fire in a cylinder itself, thereby introducing four-stroke combustion engines, were later again restricted by the laws of thermodynamics and controlled by the four-cycle sequence essential to start and end at the same point. The encircled loop for the given pair of associated intensive and extensive parameters then provides a convenient estimate of the net gain (energy, goods [36, 37, 56, 57]). This idea was subsequently developed for a wide variety of engines, turbines, pulse-jets and other power cycles [55, 56], all still governed by the same principles of thermodynamic efficiency for the external and/or internal utilization of heat/fire.

A variety of useful machinery has been developed through the human cognition (mind), but within a relatively short history of merely a few thousand years. The evolution of life, in contrast, exhibits a history several orders longer, involving billions of years, and even a living cell can be understood as a precisionally fine-tuned machine

gradually constructed through the ages as an extraordinarily sophisticated set of interrelated parts (molecules) that act together harmoniously in predictable ways, thus ensuring the progressive development, variability and selective survival of more of its kind and the efficient use of energy. Its 'know-how' experience record is coded in the DNA memory, which possesses a capacity of creative incorporation within its structure changes (internal development of a certain 'cognition'), which permits further evolution of its machinery cell into forms needed to prosper successfully upon the Earth's continuously changing face. It is clear that the space-time structures do not remain stable and some of the above-mentioned principles, such as chaos/entropy, order/information and the generalized course of cycling (making a process in such a reliable way as to exhibit co-equality of the initial and final points necessary to retain the capacity for continuous periodicity), have penetrated to other fields, such as the humanities, sociology, economics, etc. [57]. Although thermodynamics cannot provide a general law for all 'open' (highly non-equilibrium) systems, it has helped unlock important scientific insight for a better understanding of chaos as a curious, but entire source for systems evolution. All such progress, however, would not be possible without taking into account the fourth element – material (earth), too, which is acting in the form of an assembled mechanism (engine) that can be understood factually as an information transducer. It virtually contains the aspects of the early comprehension of 'ether' (and its role of an internal structure), thereby binding mind and perception ('nus') with thinking and distinction ('dianoia') and reasonableness, sanity and ability to collect known facts ('logos'). Ether can thus be associated with in-formation ('in-formare') in the sense of the evoking, formation and transmission of 'internal shape'. Within a period of generations, it gradually became evident that, to obtain useful work, one needs to apply not only energy, but also cognition [43–45] and attached information. The applied energy must either include information within itself or act on some organized subject and/or device (an engine, machinery, clockwork or even a cell) which then ultimately serves as the above-mentioned energy transducer, usually developed and invented through the self-possessed skill of generations (and hence of necessity bearing a definite value of order/information). In this way, the originally information-vacant heat/fire can be transformed to other forms of energy containing certain information within themselves. The present-day advancing exploitation of fire, on the other hand, means its effective enrichment by a certain degree of order through the inserted information provided by our manufacturing know-how, the only way to tame primarily frightening fire.

The short history of civilization is beyond comparison with the much longer history of life. The recently constructed mechanical engines can not be matched on a sophisticated level with the mechanism of living cells, which has undergone very long-lasting development. Thus, the present propensity of the fabrication of macroscopic human tools necessarily tends to avoid the undesirable aspects of self-destruction by introducing: 1. pure technologies, producing ecologically harmless by-products, 2. clean engines, producing safe wastes (their fabrication, however, usually involves higher costs of energy consumption, e.g. solar cells, which can repay their higher production costs after a long period of functioning) and 3. miniaturiza-

tion, whereby attempts are made to simulate a more efficient level of molecular tools of living cells. The so far conventional approach of 'top-down' technology starts with a large clump of material and forms it by cutting into a desirably useful shape, yet carried out mostly within the capability of our hands. Energy-saving nanotechnology would, by contrast, comprise the 'bottom-up' stacking of individual molecules directly into a useful shape, controlled by the 'power of our minds' in a similar way as proteins are assembled from individual molecules. We can contemplate the vision of a 'nanobots' age with the effective manipulation of individually small species to form miniature engines (or more imminent computers). Similarly to processing instructions on how to operate macroscopic machines (either by an experienced engineer, with the help of a printed manual or fully automatic, as controlled by a programmable computer) achieved at the one-dimensional level of a written message, we must additionally look for the analogy to microscopic instructions within the models of the three-dimensional level of the DNA structure. Such an approach is also related to the present message passed by the human cognition on the basis of the early initiated need to understand fire from its visible wholeness down to its imaginable composition of internal vibrations. This is a very important sphere of communication and of a specific message reading (necessarily to take place between people as well as individual parts of a machine), but unfortunately it lies beyond the scope of this article.

Even in the modern world with its many progressive technologies, philosophy has retained its important role in the challenge of striving to maintain a sustainable world (on the both levels of matter and mind) for the coming generations. Popper recently recalled the 'Tria Principa' of cosmic evolution grades, pointing out three appearances of the universe : 1. a world of physical contradictions ('sal'), 2. a world of significance (subjective experience 'sulfur') and 3. a world of energy (the creation of the human mind and ingenuity 'mercer'). It is somehow close to Hermetic philosophy, with prophecy (God) having the highest, and matter (earth) the lowest state of eternal vibration, everything there undergoing processes of dissolution ('solve') and integration ('coagule') within three levels : the digesting of raw materials or food on a physical level (life), breathing, based on a spiritual level (love), and meditation, based on a heavenly level (wisdom).

'We are not just observers, we are participants in the play (universe)', Bohr once said, which applies to the above story of fire, too. The struggle by mankind for a better life, while striving to survive in the universe/nature and while hunting for eternal fire, should therefore be understood as a fight for lower chaos (entropy) and maximum order (information), and no mere seeking for sufficient energy, which seems to be more or less plentiful. We should therefore not underestimate certain self-organization tendencies perceivable not only on the micro, but also on the macro level of nature [58–61] noting that 'even biospheres can maximize their average secular construction of the diversity of autonomous agents and the ways those agents can make a living to propagate further. Biospheres and the Universe itself create novelty and diversity as fast as they can manage to absorb them without destroying the accumulated propagation organization which is the basis of further novelty' [59].

The author is indebted to Prof. Zdeněk Neubauer (Faculty of Natural Sciences of Charles University in Prague), Dr. Ivo Proks (Institute of Inorganic Chemistry of the Slovak Academy of Sciences in Bratislava), Dr. Jiří J. Mareš and Dr. Pavel Hubik (Institute of Physics of the Czech Academy of Sciences in Prague), Dr. Petr Zamarovsky (Czech Technical University in Prague) and Dr. Rose Marie Flynn (STRDA, Bethesda, USA) for their comments, spirit and service as valuable sources of information. The study was supported by the Grant Agencies of both the Czech Academy of Sciences and Charles University in Prague.

The brief history of thermal science as we enter the 21st century is dedicated to the anniversary of progenitors of modern thermal analysis, retiring Dr. Joseph H. Flynn (born 1922) of Bethesda, USA and late Dr. Robert C. Mackenzie (1920–2000) of Aberdeen, Scotland. I was privileged that the early stages of this article were prepared in cooperation with Dr. Robert C. Mackenzie and it is my honor to have him as the co-author. The theme was also the subject of the Šesták's plenary lecture entitled 'Fire as an integrating element in historical thermochemistry' read at the 8th Polish Conference on Thermal Analysis and Calorimetry, Zakopane, September 3–8, 2000. The project number was Czech Academy of Sciences (No. A4010101) and the Charles University in Prague.

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Ivo Proks

„CELOK JE JEDNODUCHŠÍ AKO JEHO ČASTI"

Vybrané kapitoly z histórie exaktných prírodných vied

SVET VEDY

VEDA
VYDAVATEĽSTVO
SLOVENSKEJ
AKADÉMIE
VIED

DISQUISITIONES
DE
CALORIS
ET
FRIGORIS
NATURA.

Cujus cognitio vera in reseranda multa naturæ arcana clavis erit.

In prodromum novæ editionis Physicæ ad lumen divinum restituendæ,

A JOH. AMOS COMENIO antehac luci datæ.

Editio secunda.

IENÆ,
Apud JOHANNEM GOLLNERUM,
ANNO 1678.

28 DISQUISITIONES DE CALORIS ET FRIGORIS NATURA. 1678
Pagina tituli

SBORNÍK
JEDNOTY ČESKÝCH MATHEMATIKŮ
V PRAZE.

THERMIKA.

Sepsal

c. k. dvorní rada
DR. ČENĚK STROUHAL,
professor exp. fysiky na české universitě K. F.

Vydáno podporou české Akademie císaře Františka Josefa pro vědy, slovesnost a umění.

V PRAZE 1908.
NÁKLADEM JEDNOTY ČESKÝCH MATHEMATIKŮ.

Я. Шестак

ТЕОРИЯ ТЕРМИЧЕСКОГО АНАЛИЗА

ФИЗИКО-ХИМИЧЕСКИЕ СВОЙСТВА ТВЕРДЫХ НЕОРГАНИЧЕСКИХ ВЕЩЕСТВ

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Časopis pro pěstování matematiky a fysiky

H. Soldát

J. A. Komenského Fysika

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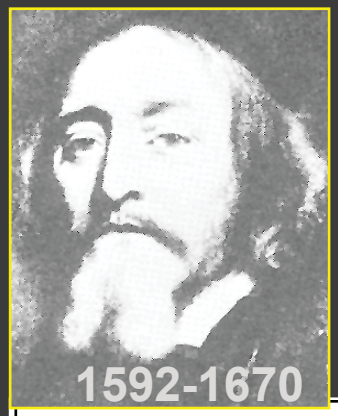
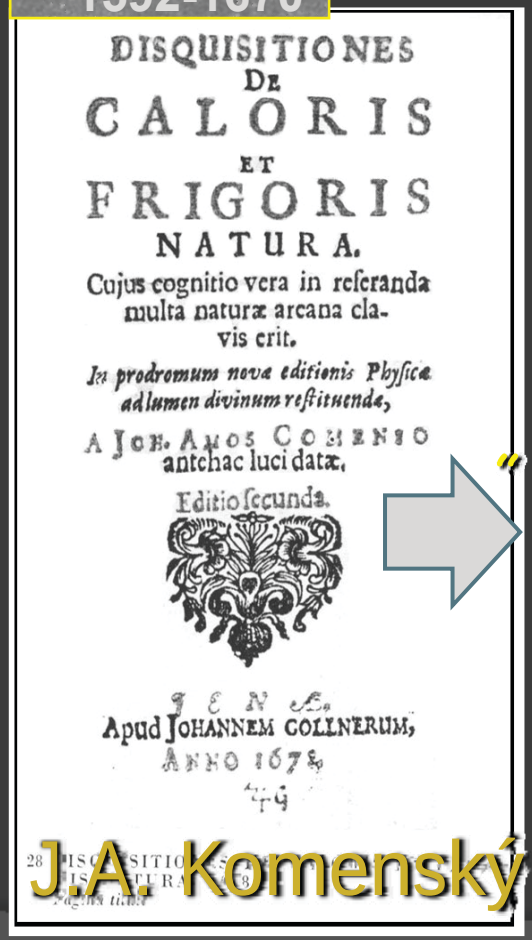

1592-1670

Význam tepla v historii

Teplo: calor, fervor a ardor
Zima: frigus, algor a ??
} tempor

„V knize "*Physicae Synopsis*", kterou ukončil 1629 a publikoval nejprve v Leipzig 1633, ukázal význam tepla a chladu (hotness and coldness) u všech přírodních procesů. Teplo (lépe oheň) je uvažován jako příčina všech pohybů a odvozeně i věcí . „*All shows therefore that both heat and cold are a motion, which had to be proved.*" Vysvětlil také funkci thermoscopu (teploměru tehdy nazývaném '*vitrum caldarium*')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Editio secunda.
Apud JOHANNEM GOLLNERUM,
ANNO 1675.
J.A. Komenský

„Abychom účinky tepla a zimy spatřili světle, sluší se vzíti předmět viditelný i sluší se prošetřovati změn jeho, když se ohřeje i zase ochladí, by se očitě ukázalo, co teplo a zima dělají smyslům pochopitelné" ⇒ **nauka o teple** (Termodynamika)

Šesták J, Mareš JJ: „*From cloric to statmograph and polarography* „ J. Thermal Anal. Calor. 88 (2007) 763

J. A. Komenského Fysika.

Obsahem a částečně překladem podává

prof. **H. Soldát.**

Na letošek připadající třístaletá památka narození J. A. Komenského vyvolala po všem světě vzdělaném nemalý ruch. Nejen slavnostmi přečetnými a výstavami uctívána památka tohoto veleducha, ale, — a to sluší více ceniti, — také literatura o Komenském právě letos byla zvláště obohacena tím, že nová podrobná konána bádání o životě jeho, i stycích a snahách, a že díla jeho znova kriticky probírána a rozbírána. U nás ovšem více bylo příčin k oslavě Komenského než v cizině, a tak i letošní naše žeň literární bude vykazovati zvláště bohatou sklizeň spisův o Komenském, jeho životě a jeho dílech. Zejména naše časopisectvo účastnilo se této literární oslavy učitele učitelů téměř bez výminky.

Žádajíc si, by také „Časopis pro pěstování mathematiky a fysiky“ v roce jubilaea Komenského přinesl některou stať z děl jeho, pokud ovšem v tento obor zasahují, vyzvala mne ct. redakce, abych část „Fysiky“ Komenského pro „Časopis“ přeložil. Neváhal jsem tak učiniti a přeložil jsem kapitolu IV. „O jakostech věcí“; avšak ježto „Fysika“*) v nečetných exem-

*) O „Fysice“ zmiňuje se K. B. Štorch v pojednání „Komenského snahy pansofické“ v Č. Č. M. 1851; obsah její naznačuje a částečný rozbor podává Dr. F. B. Květ ve článku „Obrys filosofie přírodné J. A. Komenského vůbec a jeho anthropologie zvláště“ v Č. Č. M. r. 1860; Zoubek v „Životě J. A. Komenského“ podává o ní zprávu a stručný úsudek. Pojednání důkladné a rozbor kritický podal prof. dr. J. Kvacsala, (který počítá se k nejlepším znalcům Komenského,) ve svém spise dissertačním „Uiber J. A. Comenius' Philosophie insbesondere Physik“. V Lipsku 1886.

plárech se zachovala a patří k těm spisům K-ského, jež méně jsou známy, odhodlal jsem se vedle ukázky překladu, podati obsah celého spisu.

Komenský napsal „Fysiku“ asi během r. 1632 v Lešně, kde ji před tím svým žákům přednášel, a vydal ji r. 1633 v Lipště. Kromě toho byla otištěna v Amsterodamě a v Paříži. R. 1663 vyšlo v Amsterodamě vydání druhé, jež máme před rukama.

Na „Fysiku“ Komenského nelze ovšem hleděti se stanoviska vědy nynější. Jest, jakož vůbec ještě po většině doba jeho fysiku pojímala, *filosofií přírody*. — Oba směry, jež vyvinuly se po úpadku filosofie scholastické — *mystický* a *přírodozpytný* měly vliv na Komenského. Velebí Campanellu *) a obdivuje se Baconovi Verulamskému (oba stoupenci směru přírodozpytného), avšak rovněž s úctou promlouvá o Alstediovi **) (mystik); při pozorování přírody klade hlavní váhu na *empirii* a doporučuje Baconovu *indukci*, avšak Zjevení při tom pokládá za neomylný a úcty nejhodnější pramen poznávání. — Oba tyto směry jsou tedy patrny v jeho „Fysice“, avšak Komenský spojuje je tak, že jaksi splývají. Usilovalť Komenský o to, aby uvedl v souhlas vědu a víru, snažil se docíliti jistoty a neomylnosti poznání a odstraniti spory vědecké při bádání po nejvyšším cíli, jímž mu jest *pravda*. Toto splynutí obou řečených různých směrů mohlo zdařiti se jenom tím spůsobem, že K. vystoupil ve „Fysice“ s novými samostatnými názory. Na těch nemálo si zakládá a vytýká je zejména v předmluvě k „Fysice“. Jako nové a své vlastní pokládá ve „Fysice“ mimo jiné tyto věci: *Trojici principů* (smysl, rozum, Písmo), *stupnici* (7člennou) *substancí*, nauku o *duchu* (spiritus), *pohybech* (motus) a *jakostech* (qualitates), jakž níže v obsahu podrobněji uvedemc.

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*) T. Campanella (1568—1639) mnich dominikánský a filosof. Byl odpůrcem nauky Aristotelovy. V jeho spisech jeví se snaha po svobodném bádání na základě zkušenosti. Viz „Ottův Slovník naučný“ d. V. strana 84. a 85.

**) J. J. Alstedius (1586—1638.) Byl učitelem Komenského v Herborně (1612). Ve svých spisech filosofických zakládá se na bibli, jež je mu základem a zdrojem vědění.

Jak napověděno, je snahou K-ského, by přírodovědu přivedl v souhlas s biblí, což se mu s jeho stanoviska po většině zdařilo, avšak stanovisko to bylo brzy po vymoženostech Galileiho a Newtonových na dobro opuštěno.

Než nejde nám o rozbor K-ského filosofie přírodní, nýbrž o to, bychom čtenáře s obsahem „Fysiky“ jeho seznámili. Stručný o ní úsudek připojíme pak na konec.

* * *

Jak svrchu naznačeno, máme před rukama 2. vydání spisu, jež mimo předmluvu obsahuje 303 str. 16° a nese titul

J. A. Comenii

Physicae

Ad Lumen divinum

reformandae

Synopsis.

Post annos a prima editione 28 ab ipso Authore recognita, Principiorumque mosaicarum firmiori demonstratione aucta.

Amsterodami.

Apud Joannem Janssonium.

Anno 1663.

Na prvém místě otištěn je list K-ského Janssoniovi (nakladateli), z něhož dovídáme se, že hodlal fysiku svou přepracovati a rozšířiti, zejména přehledem *astronomie*, avšak ježto požár většinu materialu zničil, astronomie pak potřebuje ještě „hřbelce“, nakladatel však naléhá, rozmnožil vydání II. jen o přídavky („Addenda“ str. 211—303.) — Následuje *Předmluva*, jež obsahuje takřka Komenského filosofické Credo a Confiteor. Je rozdělena na 38 odstavcův na 37 stránkách, a neváháme pro důležitosť její podati obšírný obsah, místy překlad.*)

*) Když byl již článek tento delší dobu v rukách redakce, vyšel 2. sešit nového vydání „Života Komenského“ od Fr. Zoubka, v němž

1. K. cituje náhled Jakuba Acontia o pisalství věku 17. jež jako rakovina prý se rozežírá, i přání jeho, by jen ty věci byly tiskem vydávány, jež obsahují něco nového a vlastní pozorování pisatelovo, aby čas věnovaný na jejich čtení přinesl nějaké ovoce. Dokládá pak K., že pravdivosť slov těch doznají zajisté ti, již musí se probírati spoustou knih, jimiž svět každoročně bývá zaplavován, jichž tituly sic jsou vždy nové a skvělé, ale obsah jest jen bůh ví kolikátý a ošklivosť vzbuzující odvar. A jakkoli také něco nového objeví se, napíší se o tom celé knihy, v nichž nové pozorování v otřepaných věcech se zahrabe, že nelze ho bez rozmrzelosti a ztráty času vyhledati.

2. Proč medle K. sám přichází také na veřejnosť? K tomu odpovídá: „*Přináším nového něco i od obvyklého spůsobu filosofování rozdílného a přináším tak, že bude, trvám, bez klamu a obtěžování kohokoli, shrnuje zajisté obsah věcí nejdůležitějších na několika listech; i přináším chtěje tímto spůsobem učiniti zadost cizím přáním.* Byl totiž po skvělém úspěchu „Brány jazyků“ roku předešlého vybízen, by vydal své filosofické názory o přírodě. A tak, jak to je v povaze jeho, přičiniti se své strany každou troškou, jež by prospěti mohla, anebo dáti aspoň příležitosť jiným, by něco lepšího na veřejnosť vynesli, odhodlal se vydati na světlo „*Přehled fysiky*“ již nedávno ve škole*) přednášel, aby jej veřejnosť posoudila, jako dílko prvější.**)

3. Nešťastný osud vyhnanství odstrčil jej — povoláním svým bohoslovce — zpět k službám školy. Chtěje se důkladně obeznámiti i s tímto úřadkem, připadl na knihy Ludvika Vivesa***) „de tradendis disciplinis“. K. lituje, že muž tak vynikajícího ducha (Vives), jehož díla se mu velmi zamlouvala, znamenaje tolik omylů, ruky nepřiložil, by nesrovnalosti urovnal. I diví

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předmluva tato je přeložena. Následkem toho p. prof. Soldát chtěl tuto část restringovati. Ježto však filosofické názory Komenského právě v tomto úvodě tak jasně a patrně se jeví, vyžádali jsme si, by celý článek ponechal nezkrácený. *Redakce.*

*) totiž Lešenské.

**) t. „Bránu jazyků“.

***) L. Vives (1492—1540) španělský humanista napsal některá vzácná díla filosofická, hlavně paedagogická.

se, že po celých sto let příliš zdlouhavě pokoušeli se o to, by mezi tolika bludy vyhledali cestu jistou a neklamnou.

4. Tu stalo se, že od některého z učenců, s nimiž stesky své v té příčině sděloval, byl mu poskytnut „Prodromus Philosophiae instaurandae“ Vlacha Tomáše Campanelly, jejž pročetl se zvláštním potěšením i největší nadějí v nové světlo; ale také dílo jeho „Realis Philosophia Epilogistica“ i knihy „de Rerum sensu“ dychtivě probíral. Mnohé se mu zamlouvalo, ne však vše. Neboť příčil se mu sám základ, *„že vše vzniká toliko ze dvou protivných principův“*. Byl K. sám o trojici principů přesvědčen z Genese, i pamatoval si z Hugona Grotia (proti Manichaeům), *že dva protivné principy jen ničí, ale netvoří.* Později také přesvědčil se, že Campanella není naprosto jist svými hypothesami, ježto v tvrzeních svých o filosofematech Gallilaeiho o pohybu země, kolísá a sám je v pochybnosť béře.

5. Když však brzy potom připadl na spis Frant. barona Verulamského „Instauratio magna“, jejž pokládá za nejjasnější hvězdu nastávajícího nového věku, poznal, že vývody Campanellovy v jednotlivostech nejsou tak pevny, jak žádá toho pravda věcí. Avšak znepokojovalo jej, že sic Verulamský pravý klíč přírody podává, ale tajemství přírody neotvírá, nýbrž toliko několika málo příklady naznačuje, jak měla by se (tajemství ta totiž) otevírati, ostatní pak zůstavuje nerozhodnuto stálým po věky pozorováním a návodům.

6. Avšak přes to vše světlo, z rozličných těch jiskřiček v pochodeň sebrané, osvítilo mysl K.-ého tak, že mnohé tajnosti přírody i temnosti Písma, jichž smysl dříve byl nechápal, staly se mu jasnými.

7. Poznal zajisté:

„I. že jediné správný, přirozený a srozumitelný spůsob filosofování jest ten, aby ze smyslu (sensus), rozumu (ratio) a Písma (Scriptura) vše se čerpalo.

„II. že filosofie peripatetická v mnohých kusech je neúplná, ale i namnoze zmotaná, rozvláčná a bludná, a tím křesťanům nejen neprospěšná, anobrž (vyjímajíc ovšem opravy a zdokonalení) škodna.

III. že filosofie může se napraviti a zdokonaliti, jestliže vše co jest a se děje, harmonicky k smyslu, rozumu a Písmu se přivádí s takovou (při všech čelnějších a nutných věcech) jasností a jistotou, že bude lze viděním viděti a hmatáním hmatati rozsetou všude pravdu každému ze smrtelníkův."

O tom však třeba poněkud promluviti.

8. Jako Campanella a jeho šťastný vykládač Tobiáš Adami, K. stanoví tři principy filosofování: **smysl**, **rozum**, **Písmo**, jež však sluší spojovati tak, by se na žádném z nich jediné nepřestávalo, nemá-li se zůstati v nevědomosti nebo pochybnosti. *Smyslem* poznáváme sic bezprostředně pravdu věcem vtištěnou, avšak pro nesčetné množství věcí i rozmanitosť tvarů mýlí on se častěji, nebo pro vzdálenosť předmětů buď nedostačuje, buď slábne, a proto nutno bráti potaz *s rozumem*, jenž dle úměrnosti věcí z podobného soudí na podobné, z protivného na protivné, a tak nedostatky smyslu nahražuje a chyby opravuje. Ale mnohé věci smyslu i rozumu unikají, a tu milosť Boží zjevila nám *Slovem* svým (t. j. Písmem), co o věcech skrytých věděti bylo pro nás důležitým.

9. Tyto tři *základy* (principy) *poznání* dlužno tedy dokonce spojovati, touží-li kdo po pravém věcí poznání. Neboť, kdo řídí se jen smyslem, nebude moudřejší prostého lidu, nedoveda si mysliti, že na př. slunce je větší země, že země je kulatá atd.; naproti tomu, kdo béře na potaz pouze rozum, bez smyslu jako svědka, rozjímaje o věcech abstraktních, zabřádá v blouznění pouhá a nový svět si vytváří, jako je Platonův a Aristotelův. Konečně, kdo jen Písma dbají, neposlouchajíce smyslu ani rozumu, buď zalétají mimo svět, nebo věcem nerozumějíce slepou víru mají, nebo držíce se litery upadají v pověry nesmyslné. Tudíž dlužno spojovati *základy poznání*, aby *Zjevení* dávalo nám víru, *rozum* porozumění, *smysl* jistotu.

10. Jest jich pak užívati v tom pořádku (totiž při věcech přirozených), že se má začíti smyslem a končiti Písmem, neboť takto každý stupeň následující od předchozího nabývá i jasnosti i jistoty i opravy. „Neboť jako není nic v rozumu (intellectus) co dříve nebylo ve smyslu, tak nic není ve víře co dříve nebylo v rozumu". Věřícímu sluší věděti, co věřiti má. Pročež Písmo pozývá k slyšení, vidění, chutnání, pozorování.

11. *Jistotu* praví K. Neboť čím je rozum smyslu bližším (t. j. čím více zkouškami smyslů lze něco dokázati), tím je realnější a naopak. Zjevení pak má více v sobě síly, čím více lze je převésti k porozumění a k svědectví zkušenosti.

12. Co týče se toho *opravování* předcházejícího následujícím, věc je správná. Neboť kde smysl nedostačuje nebe bloudí, opravuje jej rozum, a tento zase opravován je Zjevením. Na př. když smyslem pokládáme Saturna menšího Luny, když veslo pod vodou zdá se nám býti zlomeným atd., rozum jej opravuje na základě zkušenosti. A tak také rozum, když něco o věcech neviditelných nesprávně pojímá, Zjevením božím bývá opravován. Avšak takové opravování není násilné, nýbrž lahodné. Na př. Rozum nic nepřináší k opravě smyslu, co by smysl brzy rozmanitými pokusy nepoznal a sám nepotvrdil (hmat učí, že veslo pod vodou není zlámáno). A tak i víra nepřináší, co by protivilo se rozumu, nýbrž jen to a takové, jež rozum nejen připouští, jsa přemožen autoritou víry, ale i poznává, že na věcech skutečně jest. Sluší tedy za pravé míti, *že je smysl zdrojem nejen poznání ale i jistoty ve věcech přírody, rozum však nástrojem nejen poznání ale i jistoty ve věcech zjevení.*

13. *Popírají sic někteří, že by mělo býti Písmo svaté potahováno do filosofie, ježto neučí spekulaci o věcech vnějších, leč o cestě k životu věčnému.* K. přiznává, že Písmo, majíc původ božský, má za *poslední cíl učiti, přesvědčovati a napravovati*, by byl člověk dokonalý a připravený ku každému dobrému dílu. Ale každá věc má zajisté několik účelův, a jestli v přírodě každý tvor, část tvora a částička části slouží několika účelům, proč ujímati tento ráz knize nejvyšší moudrosti boží?! Jsou zajisté v této svaté knize doplňky všeho toho, k čemu smysl a rozum nedostačují, a přece nám přísluší věděti.

14. Prováděje dále tuto myšlénku, K. vykládá, že Bůh dal člověku prostředky k poznávání jeho mnohotvarné moudrosti, a ty prostředky jsou smysl a rozum. Ale jakkoli to sluší uznati, nesmí se neuznati, že všude nestačují. Vždyť nás opouštějí v poznávání věcí věčných a všech těch, jež mimo náš dohled se nalézají. Ale kde smysl schází, schází i rozum, ježto je jen obecné poznání věcí nasbírané z jednotlivých vnímání, že to nebo ono tak či jinak jest nebo se stává. Mohl-li však Bůh ne-

nahraditi toho nedostatku, že rozum a smysl nás opouštívají? A jestli Bůh v té příčině nějak o nás pečoval, kde jinde to hledati než v Písmě?

15. K. dokládá slovy Písma, že Zjevení dává poučení všude, kde smyslové a rozum nedostačují. A proč by se vykládalo (v Písmě) o stvoření světa atd., kdyby nás byl nechtěl poučiti o přírodě její otec i Písma „diktator"?

16. *Říká se, že vše to nese se k tomu, bychom učili se stvořitele věcí poznávati, jemu se obdivovati, jeho milovati a báti se.* Dobře. Ale jak to, stvořitele bez stvoření? Čím kdo lépe poznává umění malířské, tím více diví se vynikajícímu nadání umělcovu a chválí je. Povrchní poznání nevzbudí nikdy ani lásky ani obdivu. A nyní táže se K., zda pravdivo jest, co nalezáme v Písmě o tvorech, či nic? Ano-li, proč nesrovnávati to s tím, co smyslem a rozumem jsme pojali, aby vystižena byla ona pravdy harmonie, jež jest ve věcech i v ústech jich původce? A slovo Boží obsahuje zajisté nejpevnější pravdu a veškeru moudrost.

17. Marně tedy namítati, *„nenalezám v Písmě žádné zmínky, neřkuli naučení, o grammatice, dialektice, mathematice, fysice* atd. Takový zajisté je rozdíl mezi spisy božskými (Písmem) a lidskými, jako mezi Bohem a člověkem. Jako člověk, vázán jsa časem, místem a předměty, jednou dobou a na jednom místě jen jedinou věc konati může, Bůh pak věčný, všudepřítomný a vševědoucí, vždy a všude vše řídí a spravuje: tak i spisy lidské vždy jen o jediném předmětu na jednom místě pojednávají, spisy božské však nezůstávají na látce jediné, nýbrž v rozmanitých výrocích různé obsahují. Odtud může vybírati theolog, ethik, politik, oekonom, filosof atd., co kterému je s prospěchem.

18. A tímto širokým obsahem a hloubkou svou vyniká Písmo nad spisy lidské, tak že je nevyčerpatelným zdrojem moudrosti. Ať pojednává se o kterékoli materii, Písmo vždy podává ti s dostatek buď pravidel, buď výroků neb příkladů, jak dosti jasně dokázal ve svém „Triumphus Biblicus" Jan Jindř. Alsted. Že tomu tak jest, objeví se také z nemalé části v těchto fysických úvahách (Komenského).

K. cituje pak Cassiodora, že Písmo je nejvyšším zdrojem vědění, a Tomáše Lydyata, jak nemístně jednají filosofové po-

hanští hledajíce základ všech uměn v poesii Homerově, a jak křesťané, že nečiní podobně v Zjeveních božích.

19. Za to vydává K. zasloužené uznání nejkřesťanštějším filosofům Frant. Valesiovi, Lambertu Danaeovi a jiným, kteří hlásali, že sítě pravé filosofie obsaženo je v písmech svatých.

20. A tak přestává na tom, že filosofie bez Zjevení božího je nedochůdčetem. Z čehož jde, že *nelze ve školách křesťanských trpěti Aristotela jaksi za jediného učitele filosofie, nýbrž že v nich sluší filosofovati svobodně, jak vedou k tomu smysly, rozum a Písmo rovnou měrou.* Nesluší očí a uší uzavírati před přírodou. Od samých děl přírodních jako učitelů jest jim se učiti. Místo na mrtvých listech čísti jest v živé knize světa; a třeba-li vykládače, zakladatel přírody nejlepší svůj vlastní je vykládač; a při takové zkušenosti během tolika staletí najde se i lepší rádce i vůdce než Aristoteles. Neboť, jako vše lidské, i filosofie od nejprostších počátků vystupuje k dokonalosti; a za dob Aristotelových sotva překročila dětství, v pozdějších věcích (a hlavně v nynějším t. j. 17.) novými pozorováními tak je rozhojněna, že Aristotelova proti ní jeví se temnou a nejistou, anobrž zřejmé objevuje nepravdy.

21. Komenský uvádí pak Cocleniův výrok o Aristotelovi, jenž vrcholí asi v tomto: Buďsi Aristoteles sebe genialnější, sebe moudřejší, sebe učenější, buďsi vůbec vyvýšenější nad vši chválu a mocnější nade vši pohanu, přece tento div přírody *není měřítkem pravdy*, ježto nezachoval všude směr pravdy.

22. Než povšimněmež si Campanelly a Verulamského, (jež týž Coclenius nazývá Herculy, kteří vyčistili chlév Augiašův, stavě je proti těm, kdo omámeni jsou naduřilou filosofií Aristotelovou), a vizme jak často odchylují se od pravdy tvrzení Aristotelova. A proto musí býti Aristoteles i s celým svým davem z křesťanské filosofie vyloučen, aby pravdu nezamotávali v bludy.

23. Či má křesťan, jenž je naplněn pravou známostí pravého Boha a poučen jeho slovem o všech věcech viditelných i neviditelných, pravdu věcí hledati u pohanův, kteří opírají se jedině o rozum a smysly?

24. Byl to Origenes, jenž ze všech první spojoval filosofii pohanskou s křesťanským náboženstvím, snad ne v úmyslu

zlém, ale s výsledkem nejbídnějším. Chtěl snad tímto spůsobem prostému náboženství křesťanskému dodati lesku a vyzbrojiti křesťany vlastními zbraněmi proti pohanským filosofům. Leč následkem tohoto spojení Aristotela s Kristem byl ten nejtrudnější stav církve: vše bylo naplněno skřekem disputac, kacířství rodilo se z kacířství, a konečně zvrhlo se vše v antikristství. Aristoteles měl s Kristem rovný díl na utváření (ražení) článků víry, i na stanovení pravidel života, ba vlastně provozoval diktaturu, což jako v zrcadle viděti je na filosofii scholastické. Co tedy nezdařilo se muži takového nadání, jako byl Origenes, ani Tomáši Scotovi, aniž komu jinému, proč toho snášeti a neodhoditi skel, jež místo věcí obrazy ukazují?

25. *Plané jsou obavy těch, již myslí, upustí-li od filosofie peripatetické, že nebude žádné.* Naopak! Teprv pak přijde slíbená milost, pak teprv budeme θεοδίδακτοι, když odvrátíce se od věcí lidských, pouze Boha budeme poslouchati, jenž mluví skrze přírodu a Slovo. Potom bude vše pevné, šťastné, příjemné, když všechen spůsob filosofování ne na domněnkách, leč na pravdě bude se zakládati.

26. *Avšak o methodu měla by býti větší péče*, aby žákům vše tak se vykládalo, by nezdálo se jim, že se to do nich cpe, nýbrž samo proudí, od nejznámějších začínajíc a na známém rovněž končíc. *Proč nemělo by se užíti ve fysice methody mathematiky?!* kde vše samozřejmě se dokazuje, a kde vše skrze přednější a známější tak souvisí, že ani střed nebývá přeskočen, ani méně známému dává se místo, takže se popřeje souhlasu prvnímu jako poslednímu. K. diví se, že této methody dosud neužilo se ve fysice, metafysice a theologii.

27. *Ovšem čísla, míry, váhy mají do sebe více zřejmosti, než jakosti, skrze něž příroda skrytě síly své rozvíjí,* avšak větší jistoty sotva mají, když vše děje se jaksi dle věčného zákona. Však také v mathematice není vše stejně jasné; vždyť bývá různými způsoby zkoušeno, než přivede se k samozřejmosti a může býti vědecky vyloženo. Ovšem *ve filosofii nic nepraví, kdo nic nedokazuje, ničeho nedokazuje, kdo tak neukáže, že nelze odpírati.*

28. Tudíž konečně již tak jednejme, praví K. do slova, „aby školy přestaly *přesvědčovati* (demonstrare) a počaly *zná-*

zorňovati (demonstrare), aby přestaly *disputovati* a počaly *bádati* (speculari), aby přestaly konečně *věřiti* (credere), a počaly *věděti* (scire). Rovněž otrocké i záhubné je ono Aristotelovo heslo: „Žák musí věřiti" jako Pythagorovo „*αὐτὸς ἔφα*". Nikdo nechť nenutí se přísahati na slova učitelova, ale věci samy nechť upoutají rozum, a nebudiž učiteli dáváno více víry, než kolik že míti má, věcí dokázal. Nesluší se zajisté, aby ve svobodné obci literární byli *králové*, než *vůdcové;* ani *diktatoři*, ale *consulové*. A ti, již přiznávají se k umění lidi vzdělávati (formare), nechť jsou lidí tvůrci, ne soch řezbáři."

29. Kdy podaří se předkládati rozumu lidskému vše tak, by nezůstalo nejasnosti a nejistoty!? Koho třeba teprv přesvědčovati, aby věřil, že vidí, ten nevidí právě.

30. „Já", praví dále K., „ježto zdálo se mi v světle Božím viděti světlo, nemohl jsem se zdržeti, abych, Boha za pomoc pozvav, nezkusil nové věcí přírodních hypothese v novou methodu svésti a žákům této školy*) vykládati.

A z toho vzniklo, co podávám (t. j. tento spis), objevujíc podobu nové jakési (a jak doufám právě křesťanské) filosofie. Ne že bych chtěl se vzpírati radě velkého Verulamského, (jenž soudí, že by bylo upustiti od axiomat a methody, pokud by nebylo plných indukcí o všech i jednotlivých výjevech po veškeré přírodě), nýbrž aby učiněn byl zatím pokus, zda by tímto způsobem nebylo lze přivésti více světla k snazšímu pozorování tajností přírody."

31. Knihu svou nazval „*Přehled fysiky dle světla božího opravené*," poněvadž tu filosofováno jest při pochodni Písma božího, všecka pak tvrzení jsou uvedena na svědectví smyslů a rozumu, s jasností co možná největší.

32. Na námitky, že tento přehled nemá tolik jistoty a jasnosti, aby mu mohla býti dána přednosť před Aristotelovými názory dávno přijatými, K. odpovídá, že o to se nejedná, nýbrž o to, podati příklad, že, je-li Bůh vůdcem, rozum světlem a smysl svědkem, může býti pravdivěji upravena filosofie, jestliže jen by chtěli filosofové spíše pracovati pro Boha a pravdu, než pro Aristotela a domněnky.

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*) Lešenské.

Ale již tím, že vše odvozeno je ze zjevení Božích a k poznání Boha směřuje, musí býti milejší. K. chce raději blouditi veden jsa Bohem, než za vedení Aristotelova.

33. Sám doznává, že schází mnohé k oné jistotě a jasnosti, o níž se zmiňoval, avšak doufá, že opětovaným jeho vlastním nebo cizím přemýšlováním může přivedeno býti k větší dokonalosti. Řídil' se radou velkého Acontia, že povinností je každého nové pozorování přivésti na veřejnosť. A dokládá:

34. „Za nálezy nové proč medle však neměly by býti pokládány: 1.) *Principů ona trojice tak jasně dokázaná, totiž Písmo, rozum a smysl?* 2.) *proč ne substancí (podstat) podivuhodná stupnice o sedmi stupních?* 3.) *proč ne duchů oddělených i vtělených* 4.) *tolikéž pohybů i* 5.) *jakostí nauka přesněji a jasněji než dosud vyložená (přinášející zcela nové světlo vědě přírodní)?* abych o drobnějších po celé knížečce roztroušených pomlčel. Z těch neodvážil bych se zuby nehty jednotlivé v částech hájiti, (neboť některé zbyly dosud asi z obecného podání, jiné nejsou ještě podle základů položených upevněny), avšak že jsou základy nezvratné pravdy a že přičiňují k přesnějšímu pozorování každé části, jsem přesvědčen."

35. Doufá, že tato jeho methoda dodává fysice takové jasnosti, že pro pochyby a hádky zbude pramálo místa, tak že nemálo přispěje ku zničení sporů spisovatelův, když budou vědomosti všech (Aristotela, i protivníků jeho, Galena, Campanelly, Verulamského) uvedeny v harmonii. Anobrž nejen k porozumění uměním a vynálezům lidským, ale i k jich rozmnožení nějakým způsobem otevře se takto brána, což nebylo by se nikdy mohlo státi, kdyby se byli nenašli základové pravdy.

36. „Snad více mluvím, než bude čtenář za to míti, že v našich věcech najde", dí dále Komenský. „Avšak až uvidí z tohoto, jakož i ze zdroje *didaktiky* a *metafysiky* naší vyvedené potůčky (nárys *pansofie křesťanské*, jejž připravujeme,) dozná, že není to pověděno na plano. Že pak tato díla dosud nejsou na světlo vydávána, stanovím pro to, jež se vydává, zákon:

Není-li něco ze smyslu, rozumu, Písma s dostatek vyvozeno, jestliže cos s ostatními věcmi nedosti souvisí, není-li něco vlastní svou jasností dosti spolehlivo: zůstaniž nevysloveno.

Při tomto zákoně budiž mně a jiným dovoleno i pochybovati vždy a všude, *zda jedna každá věc je taková, jak vykládá se, že jest*, i pátrati, *proč taková jest, jak se býti pozoruje?* a že těmito dvěma (otázkama) nejhlubší základy pravdy konečně se vyšetří, kdož by pochyboval?"

37. K. vybízí, aby každý dbal jen pravdy. Jestli snad se klame, nechť pro lásku k pravdě ukáží mu cestu pravou; jestliže však je pravdě bližší, nechť spojí jiní svou práci s jeho, by pravda byla osvětlena.

38. Vzýváním Krista, světla světa, by světlem svým jej osvítil, by viděl zde vnější světlo tvory ozařující, i vnitřní tvory utvářující, tam pak světlo věčné, a s pozdravením křesťanských čtenářů končí K. tuto předmluvu napsanou v Lešně Polském posledního září 1632.

Po předmluvě otištěna jest báseň rektora školy Lešenské Ondřeje Wengierského „na fysiku Komenského". Po té následuje list rytíře Jana J. Czedlice, v němž vyslovuje „Fysice" největší chválu a uznání, a list Jana Jakuba Heindinia opata Bebenhúského (ze dne 28. 10. 1654), který s největší radostí konstatuje, jak názory Komenského, ač oba naprosto se neznají, srovnávají se s jeho vlastními, jenž od 50 let zanáší se filosofií.

Jest pak uveden obsah 12 kapitol i přídavku, na něž Komenský „Fysiku" rozdělil, a jimž předchází „úvod".

V úvodě vykládá se, co je fysika, co je přírodnina, dále že vědomosti o přírodě nabýváme zpytováním přírody, což však znamená šetřiti, *jak* a *proč* v přírodě každá jednotlivá věc se děje.

Zpytování musí počíti od věcí nejjednodušších, a postupovati k složitějším, neboť „natura minimis se explicat, in maximis complicat". Filosofovati o přírodě má se jen za vedení smyslu a za osvětlení, jež dává Písmo, což obšírně se dovozuje.

V kapitole I., jež nadepsána je *Idea mundi creandi et creati* K. pojednává o vzniku světa a to, jak v předmluvě dí, „ductu Mosis". Líčí (do slova) dle Zjevení stvoření světa, všude přičiňuje vysvětlení. Z nich vychází 1. že první viditelný základ

(principium) světa byla *hmota*; 2. že do hmoty té bezživotné (bruta) Bůh uvedl sílu nějakou, tak že počala se pohybovati, a to jest druhý základ (princip) světa, *duch* (spiritus) *života* všude rozšířený, jehož plný je vesmír, jenž pronikaje všechny částky hmoty, ji udržuje a řídí a dává všem tvorům jich vlastní tvar. Avšak to vše činí 3. skrze *světlo* (lux), jež *třetím* je základem světa, a to ryze činným, jež všechny věci, jež v přírodě jsou a vznikají, k místu přivádí a zařizuje. Jest pak trojí síla a úkol světla: osvětlování, vlastní pohyb a zahřívání. — I vznikl pak rozdíl mezi dnem a nocí, a také (teplem) rozdílnosť elementů, jež jsou *aether* (éther, obloha, báň nebeská), *aër* (vzduch), *aqua* (voda) a *terra* (země).

Teplem vznikly ze země mastné páry (pingues vapores), jež duch světa pronikaje způsobil, že rozmanité rostliny vyrůstaly. Když pak Bůh rozdělil světla po jednotlivých tělesech na obloze, a tak učinil hvězdy, utvořil jmenovaný duch života dokonalejší tvory, jež jsou *živočichové*. Naposled stvořen člověk, pán všeho tvorstva, podoben sic podle smíšení hmoty, ducha a světla, ostatním živočichům, Bohu však (a andělům) duší. — Aby vše co Bůh stvořil, v bytí svém mohlo trvati, nadal každou věc silou, jíž každý tvor se zachovává a množí, a jež jest *přírodou* (natura.)

Kapitola II. má nadpis „*De visilibus Mundi principiis: Materia, Spiritu et Luce.* Proti *hmotě* a *světlu* jako základům světa nebude asi námitek, co pak se týká *ducha*, (který nesmí se konfundovati s Duchem svatým), dovozuje K. jsoucnosť jeho 1. z Písma, 2. z rozumu a smyslu, velmi obratně.

Nejpádnějším důvodem je mu, že tuto trojici základů světa lze odvoditi od Trojice božské; neboť hmota je dílem Otce, světlo pochází od Syna, síla pak životní od Ducha Svat.

Tyto tři principy shledávají se v každé hmotě, neboť každý tvor má jisté množství *hmoty*, jistou *vnitřní sílu*, jíž vzniká, roste a různé účinky jeví, a *tvar*, či rozmanité spořádání částic, jež pochází od vnitřního tepla. Definuje pak tyto základy světa K. takto:

Hmota je podstatou (substantia) tělesnou, v sobě neživou a temnou, tělesa zakládající.

Duch je podstatou velejemnou, skrze sebe živou, neviditelnou a nečítitelnou (isensibilis), v tělesích sídlící a je oživující.

Světlo je podstatou o sobě viditelnou, pohyblivou, svítící, hmotu pronikající, upravující ji pro přijetí duchů, a tak tělesa utvářující.

Dle toho je hmota princip hlavně passivní, a čím více jí, tím tělo je nehybnější; světlo aktivní, a čím více ho, tím více má tělo tvaru a pohyblivosti; duch pak oboustranný (anceps); čím ho více, tím více síly a trvanlivosti.

Následuje podobný výklad o *hmotě*, z něhož vyjímáme: Prvotná hmota (prahmota) byla pára (vapor) či dým (fumus), byla chaos rozptýlených atomů. Mimo vlastnosti v definici uvedené, vytýká se, že hmota je beztvárná, avšak, že je spůsobilá, jako vosk formování, mohouc nabývati všech možných tvarův. Svým trváním je hmota věčná, a žádná její část nemůže zaniknouti. Hmotě přísluší také nerozlučitelná spojitosť, tak že nesnese ani přetržení, ani prázdného prostoru.

O duchu praví K., že přebývá ve hmotě, v níž živě se pohybuje a tak ji udržuje, že zachovává jednotlivé rody věcí a utváří (formare) si tělesa za účelem budoucích výkonů.

Světlo, jež bylo prvotně ohromný plamen a lesk, má, dle K., sílu trojí, a to: 1. rozlévati se každým směrem a vše ozařovati, 2. pohybovati hmotu, jíž uchvátilo, zapalováním a hořením, 3. zahřívati, a tím rozřeďovati hmotu. Světlo pak stalo se počátkem dnů tím, že nemohouc pohybovati se jediným směrem, pohybovalo se a pohybuje dokola; z něho odvozuje se i počátek pevné země a vody tím, že teplem vznikajícím z pohybu světla hmota zředla, a hustší části hmoty nuceny byly dolů padati a ve středu všehomíra se nahromaditi. — Touto trojnásobnou silou světla uvedena jest do světa protiva (mezi světlem a tmou, pohybem a klidem, teplem a zimou). Tudíž celé uspořádání světa od světla pochodí. A tak, končí tuto kapitolu K., „vše ve světě viditelném jest a stává se ze hmoty, za přítomnosti ducha, ale skrze oheň či světlo".

V kapitole III. — „De rerum motu" je titul její, — jedná se o *pohybu*. Ze spolupůsobení principů světa, vznikl *pohyb*,

z pohybu *jakosť*, z jakosti zase různá *změna* věcí; kteréžto tři případky *) (accidentia) každé stvořenině sluší.

Pohyb je případek tělesa, jímž z místa na místo se přenáší; dán jest tělesům za příčinou *rozplozování*, *konání* a *míry trvání* (času.) Pohyb je jednoduchý nebo složený. Následuje pak podrobné rozdělení pohybů jednoduchých, jemuž přidává K. tento

Přehled pohybů.

Pohyb jest
- ducha, jenž slove víření **) (agitatio)
- světla, jenž slove rozlévání (diffusio)
- hmoty, jenž děje se
  - ohněm, a slove
    - roztahování (expansio)
    - stahování (contractio)
  - jiným tělesem
    - působícím
      - sourodností — p. skupení (aggregatio)
      - silou skrytou — p. sympathie
      - spojováním — p. souvislosti (continuitas)
    - narážejícím, p. nárazu (impulsio)
  - vlastními částkami svými
    - p. kolísání (libratio)
    - p. svobody (libertas)

K. pak uvádí příklad všech těch pohybů na utváření makrokosmu, mimo pohyb svobody, jenž tehdy ještě nebyl, ježto nebylo žádného vnějšího násilí, jež by něco z jeho řádu vyrušilo. Tolikéž na mikrokosmu (člověku a zvířeti) ukazuje příklad všech těchto pohybů.

Pohyb složený jest ve stvořeních živých, když o své ujmě s místa na místo se pohybují.

Ve IV. kapitole „de rerum Qualitalibus“ nadepsané jedná K. „o jakostech věcí“. Pokládáme tuto kapitolu ze stanoviska fysikálního za poměrně nejinteressantnější a podáváme ji v překladu úplném.

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*) Pohyb, jakost a změna jsou *případky* (accidentia), kdežto hmota, duch a světlo jsou *podstaty* (substantiae).

**) Ovšem nelze si mysliti pohyb, jejž moderní fysika nazývá „vířivým“.

O jakostech věcí.

Rozmanitým tímto pohybem rozmanitě hmota s duchem a světlem se míší, a rozmanitým míšením rozmanité vznikají jakosti (qualitates), že tato věc takovou, ona jinou, jiná opět takovou či jinou slove a jest: což jest již vyšetřiti. Jsouť pak takové vlastnosti nebo jakosti některé obecné, všem tělesům společné; jiné zvláštní, jen jistým stvořením vlastní.

Ony buďtež zde vyloženy spolu a najednou. Tyto později na svých místech.

I. Jakosť je případek (accidens) tělesa, pro nějž jedno každé takým či jiným slove.

II. Jakosti jsou v každém tělese, rovněž tak v nehmatném (intangibile), vzdušném (pneumaticum) a prchavém (volatile), jako v hutném (crassum), hmatném (tangibile) a nehybném (fixum).

Jest totiž tělo (jak v kap. II., v popisu hmoty pouč. 8., a ducha pouč. 1. jsme viděli)

buď { nehmatné (intangibile) či prchavé, jemuž také dí vzdušné jako *duch*, *vzduch*
buď { hmatné (tangibile) totiž { *voda* i všechny kapaliny.
buď { hmatné (tangibile) totiž { *země* i všechny pevné hmoty.

Tedy těmto všem jakosti, jež vykládati budeme, společny budou. Bude totiž lze říci i o kameni, i o vodě, i o vzduchu i o duchu uzavřeném v tělese, že je mastný (pinguis) nebo surový (crudus), teplý (calidus) nebo studený (frigidus), vlhký (humidus) nebo suchý (siccus), řídký (rarus) nebo hustý (densus) atd.

III. Jakosti jsou základem všech tvárností (forma) v tělesích. Že se totiž živočich od kamene, kámen od dřeva, dřevo od ledu rozeznává, tvárnosť působí, *tvárnosť však z jakostí se ustanovuje.* Tudíž nauka o jakostech je s největším užitkem a vždy přírodní jaksi základem; a ježto bylo dosud chatrně o ní pojednáváno, bylo světlo fysiky neúplné a tak temné.

IV. Jakosť je buď vnitřní a podstatná (intrinseca et substantifica), nebo *vnější a případková* (extrinseca et accidentalis.)

O jakostech podstatných, síře, soli a rtuti.

V. Jakosť podstatná, jež vznikla prvním smíšením principů, je trojí:

vodnatosť (aquositas)	již chemikové zovou	*rtutí*
olejnatosť (oleositas)		*sírou*
pevnosť (consistentia)		*solí.*

Pozn. 1. Toto vyplývá bezprostředně ze spojení prvních základů (principů). Jak totiž na počátku duch spojený se hmotou způsobil živý pohyb vod, tak i *rtuť* není, nežli pohyb; nejpřednější kapalina, již nelze upevniti aniž hranicí pohromadě držeti. A *sůl* suchá jest a teplá, i nezničitelná, zcela tak jako duch a oheň: v ohni se uchovává, vodou nebo rtutí se rozpouští; avšak nehoří ani nedoutná, ježto je tvor obsahující nejvíce ducha (creatura spirituosissima) a naprosto nezničitelná. *Síra* však což jiného jest, než hmota ohněm promíšená. Proč miluje oheň, ne-li že je podobné přirozenosti? I jest ve složeninách hlavně hořlavinou (combustibile) či vznětlinou (inflammabile).

Pozn. 2. Nechť však nemíníš naše obyčejné nerosty, sůl, síru a rtuť či živé stříbro. Neboť jsou směsi, totiž zemina slaná, zemina sirná, kapalina rtuťná, t. j. jsou hmotou, v níž sůl, síra a rtuť převládají, avšak s příměskem jiných. Neboť i sůl má částice hořlavé, i síra něco soli, tolikéž něco rtuti; dle hlavnější (t. součástky) však děje se pojmenování.

Ony jakosti, jak samy v sobě jsou, nelze viděti, leč obrazností.*) Avšak jsou ve všem, jak chemikové zřejmě dokazují; vždyť ovšem z každého dřeva, kamene (nerostu) a t. d. vytahují (extrahunt) části surové (crudus) i vodnaté (aquosus); a tolikéž mastné a olejnaté, a co zbývá sůl jest, t. j. popel. A tak že i kapalina některá bývá rtuťnatá (mercuriosus) (jako obyčejná voda a hlen), jiná sirnatá (jako olej a lih), jiná slaná a ostrá (jako

*) Komenský pojímá tyto jakosti tudíž konkretně, označuje je nerosty, jimž sluší měrou zvláštní.

lučavka), věc sama vykládá. Že páry také některé surové, jiné mastné, jiné ostré bývají, zakoušíme v trnutí a bolestech údův.

VI. Jakosti vnitřní Bůh vzbudil, aby podstata každého tělesa založena býti mohla. Neboť

Rtuť (mercurius)	dává věcem	tekutosť, slučivosť (coitio), syrovosť (cruditas)	tudíž	nespalitelnosť,
Síra (sulfur)		ohebnosť, spojivosť (coagmentatio), mastnosť (pinguetudo),		hořlavosť,
Sůl (sal)		soudržitosť, tvrdosť, křehkosť		nezničitelnosť.

Že *rtuť* (Mercurius) dává tekutosť a snadnou slučivosť hmoty, vysvítá na živém stříbře, jež pro převahu rtuti je nejvíce tekuté, takže nelze je také utuhnouti a upevniti (sisti et figi). Tolikéž je nanejvýš surové (crudissimum), nemůže se zapáliti nebo shořeti; ano kdybys je pálil, rozprchne se do vzduchu.

Že však síra, jaksi klí, působí srážení se těles, odtud vysvítá, že v suchých, pevných a hutných (compactus) hmotách více bývá oleje (oleum) než ve vlhkých. Tolikéž, že popel, (když se síra ohněm ztrávila,) nalije-li se naň vody v kusy (massa) se nespojuje, avšak olejem neb tukem ano. Chemikové však z každého nerostu olej vytahují, i zůstává toliko popel, aniž některá část spolu souvisí.

Že sůl konečně dává soudržitosť, vysvítá z kostí živočichů, z nichž chemikové čistou sůl vytahují. Tolikéž všechny jsouce hutné, mnoho popelu (t. j. soli) po sobě zůstavují.

Velikou tudíž moudrostí Bůh tyto tři jakosti v tělesích smísil. Neboť, kdyby *rtuť* scházela, hmota by nesplývala ku tvoření (generatio) těles; kdyby *sůl*, nic nemohlo by držeti pohromadě nebo v pevný stav býti uvedeno (figi); kdyby *síra*, soudržitosť byla by násilná (violenta) a přece jen rozptylitelná (dissipabilis). Konečně, kdyby síra nebyla ve dřevinách a některých jiných látkách, nemohli bychom míti na zemi ohně,

mimo žár sluneční, (neboť nebylo by lze ničeho zapáliti), a potom kolik nedostatků utrpěl by život lidský!

O případkových čili vnějších jakostech hmot.

Až potud o jakostech podstatných; následují případkové.

VII. Jakosť případková je zjevná nebo skrytá.

VIII. Zjevná jakosť je ta, jíž lze smyslem vnímati; tudíž sluší říkati jí smyslová (sensualis). Jako teplo, zima, měkkosť, drsnosť a t. d.

IX. Skrytá vlastnosť je ta, jež toliko na základě zkušenosti se poznává, t. j. *svým účinkem* (jako láska železa k magnetu), *pročež mimosmyslová* (insensilis) slove.

Připom. Zjevné jakosti pocházejí od různého smíšení elementův a hmototvorných jakostí, skryté bezprostředně od vlastního každému tvoru ducha.

X. Smyslová jakosť podle počtu smyslů patera jest: zraková, sluchová, čichová, chuťová, hmatová, čili *barva*, *zvuk*, *chuť*, *zápach*, *omak* (tangor).

(Nechť neuráží neobvyklé slovo „tangor", tvoří se z příčiny vědecké a analogie je připouští. Neboť tvoříme-li od caleo *calor*, od colo *color*, od sapio *sapor*, od amo *amor*, od fluo *fluor*, od liquo *liquor*, od tremo *tremor*, od clango *clangor*, od ango *angor* a t. d., proč ne od tango *tangor*).*)

O jakosti hmatové (tangibilis).

XI. Jakosť hmatová či omak (tangor) je taková nebo jiná poloha částic na tělese.

XII. Jest jí pak sedmero spřežení. Každé těleso, pokud se hmatu týče, je 1. řídké nebo hutné, 2. vlhké nebo suché, 3. měkké nebo tvrdé, 4. ohebné nebo tuhé, 5. hladké nebo drsné, 6. lehké nebo těžké, 7. teplé nebo studené.

O jednotlivých těchto (vlastnostech), co že jsou a jak vznikají, bude přesně pojednati.

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*) S terminologií Komenského v překladě je potíž nemalá. K přečetným terminům, pro něž těžko nalézti případného slova českého, sluší také slovo *tangor*.

XIII. Řídkosť (raritas) je hmoty zředěné po větších prostorech rozšíření; hutnosť proti tomu hustší spěchování hmoty.

Veškera totiž země, voda, vzduch i duch brzy řidší, brzy hustší bývá. Sluší však poznamenati, že není tak hustého tělesa, aby nemělo průlinek, třeba neznatelných. Toť zjevno na nádobách dřevěných a hliněných nepolívaných, jež kapaliny jaksi propocují; tolikéž na láhvi olověné, vodou naplněné, která, je-li kladivy nebo lisem stlačována, vypocuje vodu, jako nejjemnější rosu.

XIV. Vlhkosť je tekutosť částic hmoty a jich vzájemná pronikavosť; naproti tomu suchosť soudrživosť částic tělesa a nepronikavosť.

Tak hrouda země teplem nebo mrazem shustlá, je suchá; bláto však je země vlhká. Voda jest vlhká tekutina, led však suchá voda atd.

XV. Měkkosť je navlhlý (subhumidus) stav hmoty, jenž hmatu snadno ustupuje; tvrdosť je vyschlosť hmoty, jež hmatu neustupuje.

Tak kámen je tvrdý nebo měkký, tolikéž voda, duch, vzduch atd.

XVI. Ohebnosť je spojení hmoty vlhkým klím (gluten), *že dá se ohýbati; tuhosť je sražení hmoty suchým klím, že se neohýbá, nýbrž láme.*

Tak železo tuhé jest, ocel ohebná. Tak dřevo některé ohebné jest, jiné neohebné (tuhé) a t. d. Však pamatuj si, že ohebné také *vláčným* (lentus) slove, tuhé *křehkým* (fragilis).

XVII. Hladké jest co rovností částic na hmat lahodně působí; drsné, co nerovností částic na hmat působí nepříjemně (*disé trahit*) *a bodavě* (*vellicat*).

Pozn. Při tekutinách hladké slove *jemným* (lene), drsné *ostrým* (acre). Tak mramor nespracovaný je drsný, hlazený hladký. Voda drsná jest, olej jemný. Vítr prudký a mrazivý je drsný či ostrý; vlhký vánek jemný jest. Tak také v našem těle látky vlhké, plynné a duch (spiritus) slovou jemnými neb ostrými.

XVIII. Lehkosť jest vystupování hmoty do výše následkem řídkosti nebo obsažnosti ducha (spirituositas); tíže sklon tělesa hustého dolů; jakož zjevno jest ono na plameni a všem vypařování, toto na vodě i zemi.

Pozn. 1. Jak tento pohyb vzhůru neb dolů děje se z lásky k společenstvu nebo věcem stejné přirozenosti, pověděno v kap. 3.

2. Nerovnosť tíže či váhy (ponderositas) pochází od nerovné hutnosti hmoty. Čím totiž více hmoty, tím více váží; jako kámen více než dřevo, kovy více než kameny, a mezi nimi nejvíce zlato, živé stříbro a olovo, ježto jsou nejhutnějšími tělesy.

3. Pozoruje se, že mezi všemi těžkými tělesy největší váhu má zlato; nejmenší líh čili víno sehnané. Avšak shledává se, že poměr kvantity mezi oběma nepřesahuje počet 21 dílů, tak totiž, že jedna kapka zlata 21 kapek líhu nepřeváží.

XIX. Teplo jest pohyb nejmenších částic v sebe zpět vrhaný (rverberatus), *jako by tisíce hrotů v cit tělový vnikalo* (tactum penetrans) *a jej rozedíralo* (lacerans); *zima však je pohyb částic se stahujících.**)

Pozn. 1. Že teplo i zima jsou pohyby, nikoli pevné vlastnosti, vysvítá:

a) Že zde u nás není tělesa stále teplého nebo studeného, jako bývá řídké a hutné, vlhké a suché a t. d., nýbrž dle okolností se zahřívá a ochlazuje, což od pohybu pochází.

b) Že smysl sám dosvědčuje, že při spálení kůže a údy jsou pronikány a roztahovány, při mrazu však se ucpávají a stahují: tedy jest pohyb.

c) Že, čím častěji se kterákoli věc (také kov) zahřívá, i na množství (moles) i na váze ztrácí, až se zničí; odkud však to, ne-li že teplo tisíce atomův odvrhujíc, hmotu odírá a zmenšuje.

2. Slove pohybem částic a to v sebe zpět vrhaným. Neboť, co pohybuje se v celku a přímo (nikoli nazpět), nezahřívá se, jako vítr, letící pták a t. d., avšak co se pohybuje se zpětným

*) Baco definuje teplo (1620) „jako pohyb roztažlivý, jenž děje se v nejmenších částech."

naražením či rychlým střídáním, rozehřívá se, jak děje se při odrazu světla, při opětovném nárazu těles, při odření, při tření a t. d.

3. Rozeznávati však sluší mezi *teplým* (calidum), *teplobudným* (calefactivum) a *teplovodným* (calefactile). *Teplé* či *otepłené* je to, co je ve stavu teplém (actu calet) a při doteku pálí; jako plameny, žhavé železo, vařící voda neb vzduch, (který také sám velmi prudký žár dostává) atd. *Svrchovaně teplým* (tělesem) mezi povědomými jest oheň; *svrchovaně studené* nemáme mimo led, jenž přece svým stupněm zimy nemůže býti postaven proti stupni tepla v ohni.

Teplobudné jest, co může teplo vzbuditi, jako pohyb a vše to, co pohyb může spůsobiti, totiž oheň a pepř, i všechny ostré a hořké věci v tělese. Neboť pohyb z ohně jest a oheň z pohybu a z obojího teplo. Vždyť jako oheň nemůže nepohybovati se (jinak brzy uhasíná), tak také pohyb nemůže nestati se ohněm, jak zřejmo jest z křesání křemenem a ze tření dřeva po delší dobu. Obé je tedy teplobudné, ale oheň mimo to teplý svým stavem. Teplobudná tělesa slovou obecně *teplá mohutností* (calida potentiā).

Teplovodné (calefactile) je, co snadno může se otepliti, jako vzduch a po vzduchu tuky (olej, máslo), potom dřeviny, pak voda. Ježto jsou v nich částice řidší, snadno dostanou se do úsilovného pohybu. Kameny a kovy, poněvadž mají hmotu zhustlou, nesnadno teplo přijímají, ale přijaté déle drží, ježto pro těsné póry nemůže snadno vyprchati (exhalare). A to jest příčina, že všechny hmoty skládající se z malých částic, jako peří, srstnatá kůže a všechny věci huňaté (tolikéž prach všeho druhu) teplo buď stále udržují (úsilným nějakým pohybem vzduchu v nich uzavřeného), nebo dojista snadno přijímají vzbuzenou pouze transpirací tělesem živým.

4. Sluší také poznamenati, že všechny tyto jakosti hmatové při témže tělese různě se zovou, totiž se zřetelem na těleso jiné. Jako voda, hledíc ke vzduchu, je těleso husté a těžké, hledíc k zemi nebo kameni, řídké a lehké. Rovněž tak hledíc ku hmatu, věc tak či onak ustálená, jinak a opět jinak se býti vidí. Ku př. vlažná voda horké ruce zdá se býti studenou, studené teplou.

5. Dlužno také věnovati pozornosť různému účinku tepla následkem různosti předmětu.

Účinek tepla je vždy rozředění, avšak jinak ve hmotě

- tekuté
  - *sirnaté* (sulfurea), již zapaluje, v plamen proměňuje, a vzhůru unáší (rapit);
  - *rtuťnaté* (mercurialis), již zřeďuje a rozptyluje, jakž patrno je na vypařování vod, rovněž na osýchání či vysoušení země, dřeva atd., v nichž ať cokoli je vlhkého a tekutého, teplem ve vzduch se obrací a vypařuje.
- pevné, má-li části
  - *klihovité* (glutinosae) či *sirnaté* (sulfureae), přivádí je k tání, jak viděti je na loji, vosku, kovech atd.
  - *popelnaté* (cinereae) či *solné* (salsae), přivádí je k houstnutí, následkem výsuše vlhkosti, nebo při větším úsilí, také k rozpukání, jako dřevo, hroudu, cihlu atd. (avšak takovéto ztvrdnutí je účinek tepla případkový).

O chutích.

XX. *Jakosť chuťová slove chuť, jež jest základních jakostí promíšení teplem a zimou*

neboť
- síra (smíšená, připálená) dává: chuť sladkou (dulcedo); chuť hořkou (amaror)
- sůl (dle své povahy, spálená, zmrzlá, prostř. zmrzlá, úplně zmrzlá) dává: chuť slanou (salsedo); chuť žíravou (acredo); chuť kyselou (acedo); chuť trpkou (acerbitas); ch. stahující (austeritas)

Všech těchto chutí štípavosť prozrazuje sůl.

Jest tudíž zjevno, odkud pochodí chuti bylinám, plodům, částem živočišným i nerostům: od soli zajisté a síry všude rozšířené, z nichž každý tvor podle povahy své více méně v sebe pojímá. Rtuť (mercurius) sama o sobě bez chuti jest, (jak na hlenu znamenáme); avšak jí, jakož i různými stupni tepla a zimy tyto (sůl a síra) se oslabují, že jsou více méně sladké, hořké, slané atd.

O zápaších.

XXI. *Jakosť čichová slove zápachem, jenž jest nejjemnější výpar chuti.*

Přece však spíše tělesa sirnatá zápach vydávají než slaná. Tolikéž spíše teplá, ježto teplo rozřeďuje a do vzduchu rozptyluje. Pročež zahrady a nádoby s vonnými mastmi (myrothecia), čím vzduch je teplejší, více voní; avšak čím více voní, rychleji vyčichají, když byla znenáhla ona vůněplodná jakosť sirnatá vyprchala.

O zvucích.

XXII. *Jakosť sluchová slove zvuk, jenž jest rozštěpení vzduchu následkem prudkého nárazu, které na všechny strany se šíří.*

Ne každý pohyb vzduchu způsobuje zvuk, nýbrž jen pohyb jímž vzduch rychle se rozráží a rozštěpuje. Jest pak zvuk vysoký nebo hluboký, příjemný nebo nepříjemný, dle toho, zda těleso, jež na vzduch narazilo, bylo ostré nebo tupé, hladké nebo drsné. Přirozené druhy zvuku jsou: *znění* vzduchu něčím ostrým rozechvěného; *bublání* vody padající; *hřmění* blesku; *šelest* listí; *bučení* nebo *řvaní* hovad; *řev* lvů; *sykot* hadův a hlasy jiných živých tvorův.

O barvách.

XXIII. *Jakosť zraková slove barva, jež jest světlo různým způsobem na povrchu těles přijaté (receptum) a smíšené s temnem proti němu se nalézajícím; jako běl, čerň, zeleň* atd.

Pozorov. 1. Že barva sama o sobě ničím není, než světlem od věcí různě odraženým, vysvítá:

1. že, jakož beze světla se nevidí, tak ani některým jiným smyslem nebo řečí nemůže se jsoucnosť něčeho dokázati, a tudíž není;

2. že barvy,*) rovněž jako světlo, skrze vzduch se šíří a v oko všech hledících dopadají (incurrunt); že však pohyb ší-

*) V orig. vytištěno calores, ovšem chybně.

řivý je světlu vlastní, svrchu jsme viděli. Tudíž v pravdě barva nic jiného není, než různými povrchy těles různě zbarvené světlo;

3. že světlo na téže hmotě jinak odražené, jiné a zase jiné budí barvy. Vidíme to ku př. na oblaku, jenž sám sobě rovný, jeví se přece brzy bělavý, brzy černavý, brzy zarudlý, dle toho, jak proti světlu je postaven. Tolikéž na duze, (jež není nic jiného než rozplynutí oblaku v nejmenší kapky vodní), vidíme barvu žlutavou, zelenou, ohnivě červenou i modrou, jakož je i zřejmo v hranolu křišťálovém obráceném proti světlu. Vše to zajisté dokazuje, že *barva* nic jiného není, než různé zbarvení světla od různého jeho dopadu. Avšak pomíjející jsou barvy tam (v duze a sklu), ježto hmota sama pomíjející jest a průhledná; na tělesech pevných lpí také barvy pevně, ale spůsobem spíše známým Bohu než nám.

Pozor. 2. Dle toho, jak barvy přijímá, slove těleso *průhledné* (pellucidum) nebo *tmavé* (opacum). *Průhledné* (průsvitné) jest, co světlo propouští a tak ani se nezbarvuje, aniž je viděti, jako vzduch, a z části voda, sklo, křišťál, diamant atd. (Že vzduch se nezbarvuje, t. j. světlem nebarví, je patrno ve světnici úplně uzavřené. Vpustíš-li skulinou paprsek sluneční, proběhne sic celou světnicí, a přece nebude patrným, leč na protější stěně nebo na podlaze; nebo jestliže ruku nebo nějakou jinou pevnou hmotu předsouvneš, nebo, jestliže vzbouří se prach a částice jeho v takovém množství poletují, že mohou světlo odrážeti. *Temné* jest, co světla nepropouští, nýbrž odráží a tak se zbarvuje a stává viditelným, jako země, dřevo, kámen, drahokamy i barevné vody: avšak *toto od tmavého tělesa odražené světlo vlastně* **barvou** *slove*; jíž je šestero druhů: *bílá, žlutá, zelená, červená, modrá, černá.*

Bílá barva — či běl, je světlo odražené ve své vlastní podobě.

Žluť je světlo zbarvené málem temna.

Zeleň je světlo ze směsi velmi lahodné, s polovice světla a stínu.

Červeň je světlo více k temnotě se chýlící.

Modř je světlo více jak z polovice ztemnělé.

Černí konečně jest, neodráží-li se světlo pro temný povrch. Kterákoli tato barva má v sobě různé stupně a odrůdy, podle různého s jinými smíšení, což přenecháváme pátrání optikův a malířův.

XXIV. *Zbývá jakosť, již vnímáme dvojím smyslem, hmatem i zrakem, totiž* **tvar**, *jímž některé tělo je kulaté, jiné podlouhlé, jiné čtyrhranné atd.* Avšak jej vyšetřiti je mathematikům zůstaveno.

O jakosti skryté.

XXV. *Jakosť skrytá je síla v jiné těleso nějak působící, což nepostihuje se leč účinkem.*

Ku př. že *magnet* železo přitahuje; že *jedy* v tělesech jen na ducha míří a jej utracují; že *protijedy* zase jedům vzdorují a proti nim ducha chrání, že některé byliny mozku, jiné srdci, jiné játrám zvláště slouží, a pod. Takovéto skryté jakosti Bůh po celé přírodě rozšířil, a jsou větším dílem dosud utajeny. Pocházejí však bezprostředně od vlastního každému tvoru ducha. Neboť jako jedna a táž hmota světa skrze rozličné spojení a pro ně v kamenech, kovech, rostlinách a zvířatech nesčetných jaksi tvarů dosáhla, tak jeden a týž duch světa (Spiritus Mundi) skrze různé a zvláštní, Bohu povědomé mohutnosti (virtutes) do nesčetných tvarů jest uveden. Z těchto však skrytých jakostí vznikají vlastně sympathie a antipathie věcí.“ —

Další kapitoly podáváme pak jen v stručném obsahu.

Následující *kap. V.* „De Rerum Mutationibus, Generatione a Corruptione etc.“ věnována je věcí *proměnám*, jimž vše ve světě podléhá, a jichž příčinou jsou protivné jakosti, zejména teplo a zima. — *Proměna* je případek tělesa, jímž se mění jeho bytí. Týká se těles všech. Je buď *bytná* (essentialis) nebo *připadková* (accidentalis). Bytné změny jsou *splození* (generatio) a *porušení* (corruptio) t. j. počátek a konec bytí. — *Případkové* jsou *přibývání* (augmentatio), *ubývání* (diminutio) a *zjinačení* (alteratio). — K plození vyžaduje se trojí: *símě* (semen) t. j. částečka hmoty, jež v sobě chová ducha života (spiritus vitae), *mateřník* (matrix) t. j. místo vhodné pro uložení semene, by toto svou mohutnosť mohlo rozvinouti, a

mírné *teplo* (calor), jež je pohyb v semeni vzbuzený, který hmotu jeho rozřeďuje a působí, že se rozšiřuje. Duch pak ustavičným pohybem proniká části a utváří si podle své povahy bydliště podobné tomu, z něhož sám byl vyšel (t. j. nový plod zachovává svůj rod). — Vše splozené roste a zvětšuje se (augmentatio) přitahováním a spodobňováním hmoty; avšak to jednou přestává a nastává *ubývání* (diminutio) následkem vysychání (arefactio) hmoty. Ježto pak žádné těleso nedrží stále tytéž vlastnosti, nýbrž je různě mění, nastává *zjinačení* (alteratio).

Každé těleso podrobeno je *porušení* (corruptio)*), jež děje se *vysýcháním* (arefactio) nebo *hnitím* (putrefactio). Prvé nastává, když tělesu nepřibývá hmoty, a teplo pozbyvši vlastní vlhkosti, zbývající částice vysušuje, tvrdými činí a konečně opouští; druhé, opustil-li duch těleso a části hmoty se rozpadávají. Avšak, ježto při *porušení* žádná část hmoty se nezmaří, ani duch neodumírá (suffucari), aniž světlo hasne, nic pak z toho mimo tento svět neuniká, nýbrž vše se proniká, a vzrůstá opět jedno z druhého, lze za pravé míti, že „porušení jednoho, je splozením jiného", a že svět mohutností svou je věčným.

K. pojednav o principech i o výsledcích vzájemného jich působení, totiž o pohybu, o jakostech i proměnách hmot, přistupuje k tomu, aby vyložil, jak z těchto principů druhy věcí vyvozeny jsou. Vše co ve přírodě je, rozdělil K. na sedmero tříd nebo skupin, jež tvoří jaksi řebřík o 7 stupních (v. str. 258); mezi těmi skupinami jest pak vztah ten, že, ač každá vyniká zvláštními mohutnostmi, následující, jsouc jaksi vyšší, mohutnosti předcházející v sobě obsahuje. O tomto rozčlenění a podstatě jeho při *„doslovu"* ještě se zmíníme, podotýkajíce na tomto místě, že těchto „sedm stupňů" tvoří: *živly*, *pára*, *nerosty*, *rostliny*, *zvířata*, *lidé a andělé*, jimž následující kapitoly „Fysiky" po jedné jsou věnovány.

V kap. VI. „De Elementis, Aethere, Aëre, Aqua, Terra" jedná se o *živlech* (elementa), jichž K. čtvero rozeznává, a to éther, vzduch, vodu a zemi. Jest pak živel „těleso" v přírodě

*) K. vykládá, že název *corpus*, tolik co corrupus, pochází od toho, že je (tělo) corruptioni subjectum.

prvotní a přirozeností nejjednodušší, jež vytvořeno účinkem světla, které pohybem svým a teplem částice hmoty různě rozředilo.

Následkem různé hustoty této utvořilo se čtvero odrůd hmoty světové, jež jsou řečené 4 živly, z nichž nejřidší a nejjemnější a tudíž nejvyšší prostor světa zajímající jest *éther*, pod ním je *vzduch*, pak *voda*, jež je již hustší část hmoty a to skapalněná, nejníže pak jako ssedlina je část nejhustší, a tou je *země*. Tedy *živly* jsou touž hmotou světovou líšící se jen hustotou, pročež může živel v jiný se proměniti. Jako z „atomů" je hmota živlů složená, tak může se zase v atomy rozpadnouti.

K. vyloživ vzájemnou polohu živlů, vykládá, že země je „věčně klidná" t. j. nehybná*), nad ní plove voda, nad tou poletuje vzduch, nad nímž se vznáší éther. Avšak část vod položena je nad nejvyšší éther, jakož část ohně étheru položena je v nitro zemské. Že toto není paradoxní, K. dokazuje z Písma i cestou rozumu. Pojednav ještě podrobně o každém živlu, což neposkytuje valného interessu, dospívá ku

kap. VII. „de Vaporibus". Světlo zahřívajíc a rozřeďujíc živly rozpouští je v páry, z nichž, zhoustnou-li opět, nejrozmanitější rody věcí se plodí. A o těchto *parách*, (jež tedy mají původ ve hmotě světové), jedná dále K. *Pára* (vapor) je živel | zředěný jinému živlu přimíšený; plodí se působením tepla, jež hmotu těles rozřeďuje, ze živlů hustších (země, vody a vzduchu). Veškerý svět jest naplněn parami, tak jako by byl svět velké „vaporium" (pařiště).

Páry samy vznikají, aby původ daly věcem, neboť jsou látkou (materia) všech věcí. Ovšem srážejí se jinak v těleso kapalné, jinak v těleso pevné. Pohyb jich, (ježto řidší jsou) směřuje vzhůru. Vlastnosti mají podobné jako hmoty vůbec, jsouce vlhké nebo suché, řídké nebo husté, jemné neb ostré atd. Nahromaděním spůsobují páry *vítr*, na moři *příliv*, na zemi *zemětřesení*.

*) K. skládal svou „Fysiku" v témž roce, kdy vyšel Galileiho proslulý „Dialog". Ostatně na jiném místě čtenář sezná, že byl K. odpůrcem Koprníkovým.

Následuje pak výklad o větru, příčinách jeho i druzích. Podobně o přílivu a odlivu, jehož příčinu dlužno hledati v parách nitra zemského, které oheň podzemský spůsobuje. Příliv a odliv mění se dle pohybu a postavení slunce a měsíce. — Zemětřesení vzniká následkem nahromaděných podzemních výparů (exhalatio), jež východu hledají.

Kap. §*VIII.* jedná „de substantiis concretis: Sideribus nempe, meteoris et mineralibus.“ Co nazývá Komenský *concretum*? Jest to pára (vapor) sražená, obdařená tvarem nějakým. Dle toho užíváme pro to (dle Květa) slova *sraženina*. Prvá příčina sraženin je zima, jež páru zhušťuje a sráží. Jsou pak sraženiny étherové, vzduchové, vodní a zemní. Sraženiny étherové jsou hvězdy a vlasatice. Hvězdy jsou ohnivé koule, plné světla a tepla, jimiž se éther se všech stran třpytí. Bůh rozložil po nebi kol kolem hvězdy v počtu převelikém, by zemi se všech stran ozařovaly a rychlým pohybem hoření obíhaly ve své sféře. O této hvězdné sféře vykládá pak *K.*, že pohyb její vykoná se ve 24 hodinách, a ježto je kruhový, že děje se mezi dvěma stěžejemi či body nehybnými, t. j. póly. Mezi těmi póly pohybuje se nebe, opisujíc největším svým zaokrouhlením uprostřed mezi oběma póly kruh, jejž *rovníkem* nazývají. Poloha, kde hvězdy nad zemi se vynořují, slove *východ*, protější, kde se ponořují, *západ*. Vykládá pak o ohromné velikosti stálic, z nichž největší zeměkouli převyšuje 107krát. Hvězd, jež lze spočítati, jest 1022, avšak že Bůh zná jich nesčetné množství, vysvítá na př. z mléčné dráhy, i Písmo to dotvrzuje. Zmiňuje se pak o znameních nebeských a o zvířetníku. Vzdálenosť sféry hvězdné činí 20.000 poloměrů zemských, po 900 něm. mílích.

Největší díl žhavého světla nahromaděn jest na slunci, tak že vidí se býti jaksi jediným zdrojem světla i tepla. O *slunci* pak dovídáme se, že bylo učiněno tak velkým, by stačovalo k osvětlování celého světa a k zahřívání a vypařování celé země: totiž 160krát tak velkým jako země; že bylo do takové vzdálenosti vyzdviženo nad zemi, aby ji ani nespálilo ani zase nenechalo na holičkách, že je zemi 10krát blíže než sféra hvězdná. Pohybem volnějším než sféra hvězdná, jímž téměř o 1^0 zůstává denně pozadu, stává se, že za 365 dní „jaksi zpátečním pochodem celou sféru obejde a za tolik též dní k téže hvězdě se

vrací.“ Což zoveme *roční dobou* nebo *slunečním rokem*. Tento zpáteční postup děje se ne v rovníku, než pod zvířetníkem, čímž vysvětlují se roční doby. Za pomocníky přidány jsou slunci „hvězdy bludné“ (oběžnice), jež liší se svou polohou, během, velikostí a světlem. Jest jich šest, a to tři nad sluncem: Saturn, Jupiter a Mars a tři pod sluncem: Venuše, Merkur a Měsíc.

Že hvězdy buď výše buď níže na nebi se vznášejí, vykládá *K.* týmž způsobem jako různou výšku oblaků ve vzduchu, nebo proč některé dřevo více, jiné méně ve vodě se ponořuje. Příčina je různá hustota hmoty a světla. Planety horní jsou větší, dolní menší země. Čím která vyšší, tím rychleji, čím nižší a zemi bližší, tím volněji se pohybuje. Jest ještě stručná zmínka o oběhu oběžnic, hledíc k oběhu slunce i jich světle. — O *vlasaticích* se praví, že jsou to hvězdy, jež někdy svítí a opět hasnou. Nejsou to vznícené páry (vapores), nýbrž odraz sluneční v parách, což *K.* podrobně dokazuje. Ze jsoucnosti vlasatic vysvítá, 1. že celé nebe se pohybuje, a ne pouze hvězdy; 2. že je tekuté a průchodné a ne jako křišťál tvrdé; 3. že páry (vapores) až tam vystupují, a že všude ve světě viditelném dějí se změny.

Uvedli jsme obsah „astronomie“ Komenského poněkud podrobněji, aby patrno bylo, že jevil se býti odpůrcem Koprníkovým, jehož díla dobře znal. (V knihovně Nostické v Praze chová se rukopis Koprníkova díla „De orbium coelestium revolationibus“ s podpisem Komenského.) Věc vysvětluje se ovšem snahou Komenského vykládati vše z Písma, jako zdroje poznání a vše uváděti v souhlas s tímto zdrojem.

Sraženiny vzduchové nazývá K. *meteory*. Vznikají stálým stékáním výparův ode všech živlů denně, bývají však trvanlivosti nepatrné. Jsou pak *meteory vodní* (z vlhkých výparů) a *žhavé* (ze suchých výparů).

Meteory vodní jsou mlha, oblak, déšť, kroupy, sníh, rosa, jíní, o jichž vznikání se pak dále jedná. *Žhavé meteory* pocházejí z mastného dýmu, jenž vzňal se ve vzduchu; jsou pak: padající hvězdy, létací drak, blesk, blýskavice, bludičky, čistění hvězd a ignis lambens.*) Všechny tyto druhy *K.* jednotlivě po-

*) Ignis lambens jest výpar mastný, pochodící z tělesa živého pohybem zahřatého, u jeho hlavy neb na blízku. — Zdá se nám, že míněn tu úkaz známý nám jménem oheň Eliášův.

pisuje. O blesku na př. praví, že „jest oheň vznícený uprostřed mraku, jenž mijí protivnou zimu a s rachotem hrozným vyráží a velmi často plamen až na zemi vrhá.“

Mimo to rozeznává K. ještě *meteory svítící* (m. apparentia), jež jsou okolek měsíce a slunce, tvárné slunce, tvárný měsíc, pruhy (pije-li slunce vodu), červánky, duha.

Sraženiny vodní jsou bubliny, pěna, led a rozmanité úkazy ve vodě; také k nim počítá mořskou sůl, pramenitou vodu a vody léčivé. Následuje pak pojednání o *sraženinách zemních* či *nerostech*, jež jsou zhuštěniny zemní, spojené podzemními parami, jako zeminy, zhoustlé šťávy, kovy, kameny atd., o nichž jednotlivě děje se výklad.

Kap. IX. má nadpis „de Plantis“ a věnována je rostlinám. *Rostlinu K.* definuje jako „sraženinu živoucí, ze země vyrůstající, jakož je strom, tráva atd.“ Vykládá pak o účelnosti rostlin i jich podstatných částech. Duch rostliny slove duchem *vegetativným* či *rostlinným*, jenž trojím směrem své působení jeví, a to: výživou, vzrůstem a plozením, což vše *K.* podstatně vykládá. Potom následuje stať o zvláštnostech a druzích rostlin.

Kap. X. („de Animalibus“) věnována je zvířatům. *Zvíře* je K.-ému rostlina samohybná, nadaná smyslem. Touto samohybností rozeznává se zvíře od rostliny. Princip pohybu ve zvířeti je *duše životná* (anima vitalis), jež je živý duch, který tělesa, v nichž sídlí, naplňuje a svou mocí řídí. Sídlem *ducha zvířecího* je hlava; k ostatním úkonům slouží ústrojí oživující (mozek a srdce), ústrojí pohybující (nohy, křídla), smysly (zrak, sluch, hmat, čich, chuť), ústrojí výživná (huba, zuby, žaludek, játra), ústrojí rozplozovací, jazyk (k vytváření zvuku) a jako zbraně a štíty dány jsou zvířatům rohy, zuby, drápy a tolikéž srsť, štětiny, šupiny, škořápky atd. Dle toho tedy shledává se na zvířeti sedmero schopností či mohutností, a to: 1. vyživovací, 2. životní, 3. čijící, 4. pohybovací, 5. projadřovací, 6. obranná, 7. rozplozovací. O tomto sedmeru rozmanitých mohutností *K.* podrobně a obšírně vykládá na 31 stranách.*) Zakončena pak je tato kapitola statí o druzích zvířat.

*) Kapitolu tuto sluší s následující počítati k anthropologii Komenského. O té pojednal Dr. F. B. Květ v „Časopise Musea král. česk.“

Kap. XI. („de homine"), v níž jedná se o *člověku*, tvoří vlastní „anthropologii" Komenského, ač sluší k ní počítati již předešlou kapitolu, ježto v ní podstatná část anthropologie jest obsažena. „Člověk je zvíře rozumné, obdařené duší nesmrtelnou." Skládá se ze tří částí, jež jsou *tělo*, *duch* (animus) a *duše*. Tělo je nástroj a sídlo (habitaculum) ducha, duch však sídlo a nástroj duše. Tělo dáno člověku, by všem účelům duše nesmrtelné sloužilo, proček je vystrojeno větším počtem ústrojí (orgánů), přímé a nahé, jaksi volné. Duch dán je člověku bohatší a ryzejší, a tím jsou i jeho výkony více vynikající, totiž pozorlivosť (attentio) bystřejší, obrazotvornosť (imaginatio) mohutnější, paměť (memoria) pevnější, vášně mocnější. Po obšírném psychologickém výkladu těchto výkonů ducha, přechází K. k důkazu (zvláště na základě Písma), že duše lidská bezprostředně od Boha pochází; jest však jen utvořená (formata) z ducha světa, ovšem zdokonalená a ryzí. Duši přísluší tři mohutnosti, totiž *rozum* (intellectus), *vůle* (voluntas) a *svědomí* (conscientia). Následuje rozbor a výklad těchto mohutností obšírný. Avšak ani rozsah tohoto článku, ani úkol „Časopisu" nepřipouští, bychom uváděli podrobný obsah, i odkazujeme v té příčině k poznámce na str. 228. Ostatně zvláště činíme čtenáře pozorným na svrchu zmíněný již výborný rozbor J. Kvacsalův „Über J. A. Comenius' Philosophie insbesondere Physik."

K. končí kapitolu o člověku důkazem, jak právem nazývá se člověk μικροκόσμος a nebo τὸ πᾶν.

Kap. XII. jedná o andělích („de angelis"). *K.* přijal tuto stať do Fysiky, „protože andělé jsou částí světa stvořeného a že nejblíže v stupnici tvorů jsou člověku, z jehož přirozenosti snáze přirozenosť andělů se vyloží." Následuje důkaz, že andělé skutečně jsou, že jsou lidé bez těla (incorporeus), že byli stvořeni přede vším jiným a to z ducha světa jako tvorové dokonalí. Ani se nerodí ani neumírají. Jich počet je jaksi nekonečný a bydlištěm

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r. 1860, ovšem dosti kuse. V II. vydání Zoubkova „Života J. A. Koménského," jež pořádá Dr. J. V. Novák, jak ze 2. sešitu právě vydaného patrno, této stati zvláštní věnována je pozornosť a mnohé z ní přeloženo. Proto bylo nám lze omeziti se na obsah nejstručnější.

nebe nebes. K tomu přistupuje výklad, proč byli stvořeni, a o jejich mohutnostech.

V doslovu, jenž potom následuje, praví K.: „A tak viděli jsme, že svět stvořený ryzí je harmonie. Vše z Jednoho, vše k Jednomu. Poznali jsme, že vše, co vidíme, složeno je ze tří principů: hmoty, ducha a světla, ježto ten, jenž je počátek a konec všeho, *trojjediný* Bůh jest, z něhož, skrze něhož a v němž vše jest. Poznali jsme i podivuhodný, vystupující žebřík o sedmi stupních tvorů z principů vznikajících. Neboť cokoli jest (mimo Boha), buď jest živel, nebo pára (vapor), nebo sraženina (concretum), nebo rostlina, nebo zvíře, nebo člověk, nebo anděl, a do těchto sedmi tříd, jak poznali jsme, veškeré množství tvorů se rozděluje. V jednotlivých těch vynikají jednotlivé mohutnosti (virtutes) prýštící se z bytosti Stvořitele. Neboť

v	živlech parách sraženinách rostlinách zvířatech lidech andělích	vyniká	bytí pohyb tvar či jakosť život smysl rozum poznání (intelligentia).“

Že tato stupnice je správná, přečetnými citáty Písma K. dokládá. A tak sám uspokojen končí, velebě nadšeně Pána. —

Připojen jest pak *Přídavek o nemocech těla, ducha i duše* (Brevis Physicae appendix de corporis, animi, animaeque morbis, eorumque generalibus remediis) na 12 stranách.

Druhé vydání své „Fysiky“ Komenský rozšířil a doplnil „doplňky“ („Addenda“). Tyto doplňky tvoří vlastně 5 kapitol nového zpracování „Fysiky“ a to kap. II.—VI. Že Kom. pomýšlel na to, Fysiku svou přepracovati, vysvítá z dopisu k Jansoniovi (cit. na str. 259.), a že vůbec zanášel se za svého pobytu v Amsterodámě opět bádáním přírodozpytným či spíše filosofií přírody, dokazují tito spisové tamže vydaní: „Disquisitiones de caloris et frigoris natura“ (1659), a „Cartesius cum sua naturali philosophia a mechanicis eversus“ (1660).

V „doplňcích“ K. nikterak se neodchyluje od názorů svých, jak vysloveny jsou v I. vydání „Fysiky.“ Ovšemť jeví se v nich některé nauky jeho valně rozšířeny a prohloubeny. Tak první 4 kapitoly (II.—V.) „doplňků“ obsahují na 84 stránkách, co v I. vyd. v kap. II. je na 16 str. — Budiž pro úplnosť podán aspoň stručně obsah také těchto „Addend.“

Kap. II. nadepsána je „De Visilibus Mundi Principiis, *Materia*, *Spiritu*, *Luce*, in genere.“ *K.* odráží tam námitky, jež pronášeny byly hlavně proti *duchu života* (spiritus vitae), či jak také dí *duši světa* (anima mundi), háje jej proti filosofům (paripatetikům), již tvrdí, že tvar věcí pochází jediné z potence hmoty, i proti theologům, kteří u Mojžíše (v Písmě) nechtí viděti žádného ducha stvořeného, nýbrž toliko Ducha svatého. *K.* vyvrací jich námitky 1. svědectvím znamenitějších filosofův a theologův a samého Písma, 2. nejpevnějšími důvody rozumovými, 3. nezvratnými zkušenostmi, jež smysly podávají. — Zvláště dává si záležeti *K.* na tom, by dokázal, že tento „duch“ je ve všech tvorech, t. j. nejen ve zvířatech, ale i v rostlinách, anobrž v nerostech. Ovšem uvádí také důvody, jež se stanoviska moderní přírodovědy budí úsměv, na př. „že tráva vyrůstá ze země bez semene“, kteréžto zjev ovšem prý nedá se jinak vysvětliti, než působením ducha a j. Interessantní je, co *K.* vykládá (mnohem obšírněji než v II. kapitole „Fysiky“) o spojení a působení tří principů v tělese, a což vrcholí v tom, že „hmota je udržovatelkou (sustentatrix) tvarů, duch jich budovatelem (architectus), světlo spojovatelem (conciliatrix). Vždyť hmota bez ducha je věc mrtvá, beze světla svázaná. Duch však bez hmoty nezůstal by, (nejsa učiněn, aby zvláště existoval, jako duch andělský), beze světla nebyl by činným, jsa svázán pouty hmoty. Světlo konečně beze hmoty, své potravy, nebylo by i uhaslo by, a bez ducha nic by neutvářelo, ježto je úkolem ducha tělesa utvařovati.

Kap. III. jedná *o hmotě* „de prima et ima Corporei Mundi basi, *Materia* omnia sustentante.“ „Hmota světa prvotná (prahmota) byla jakási spousta (moles) tělesná, po celé stvořené propasti (abyssus) rozšířená, učiněná z ničeho, aby z ní mohlo vše býti učiněno; sama beztvárná, aby byla všech tvarů schopna; množstvím svým srovnávajíc se s množstvím světa, by vše vyplňovala a nic nezůstalo prázdno; jako dým nebo pára všemi částmi spolu souvisíc

všude, a přece všude průlinčitá, a tak jako houba roztažitelná a stažitelná; a tudíž viditelná nebo neviditelná, podle stupně hustoty nebo řídkosti; konečně však tak trvanlivá, že nic z ní nikdy zajíti nemůže.“ Tuto definici hmoty Komenský kus po kuse vysvětluje a z Písma a z rozumu dokazuje. Zejména odpírá důrazně tomu, že hmota je od věčnosti a četné důvody proti tomu uvádí, konče slovy: „Summou, všecky důvody rozumové vítězně vymáhají, že *dřív musilo se něco státi z ničeho, než něco z něčeho, aby všech věcí, jež jsou, v pravdě byl jediný počátek.* Zůstaniž tudíž, co mnozí tvrdí: *Hmota prvotná* (prahmota) *fysiků, je (známé) „nic“ theologův.*

Kap. IV. má nadpis „De prima, omnia in Mundo continente et vivificante Vi, *Spiritu* universali, seu *Anima* Mundi.“ „Duše světa je spousta duchová, nesmírná, živá, spoustě tělesné nejprv Bohem vlitá, by ji celou obývala, oživovala, v jednotě pohromadě udržovala a z ní jednotlivá tělesa (podle přidělených sobě ideí) utvařovala, zachovávala, a v nich a skrze ně vše rozumně konala, a to i bez konce, kdyby se Bohu Stvořiteli zlíbilo, věčný věcem ponechati běh.“ A zase (jako při hmotě) kus po kuse rozebírá, vysvětluje, dokazuje a z Písma dokládá. Dle tohoto výměru musí míti každá věc se svým duchem rozum (rationabiliter praví se tam). A *K.* tomu horlivě přisvědčuje.

Jako pak hmota na tři tvary(formae) rozdělena byla, vzdušnou (spirabilis),*) tekutou (fluida) a pevnou (consistens), tak i duch je trojí: 1. *přírodný* (naturalis), jenž tvoří základ života, jsa přes všechny živly rozšířen, 2. *životný* (vitalis), zdroj růstu (vegetatio), převahu mající v říši rostlinné, 3. *živočišný* (animalis), vůdce smyslu a pohybu místního, panující v živočiších.

Na konec odpovídá K. na otázky: „Zda je duch (animus) a duše (anima) totéž“ a „zda všechna tělesa duchem všeobecným naplněná, rovnou měrou jako na životě i na čití mají účast?“ K první otázce odpovídá: „Duch je substancí v sobě živou, smyslem nepozorovatelnou, účinkem jediné se jevící; duše však jest tělesa některého hostem (hospes) a činnosti jeho ředitelkou.“ Ku druhé otázce přisvědčuje tak jako F. Patritius a T. Campanella, dokládaje na konec, „ježto duch všeobecný živý jest

*) V kap. III. §. 30. „dodatků“ říká K. také jako jinde „volatilitas“.

a zdrojem života, s životem pak nerozdílně spojeno jest čití, dlužno za to míti, že jak velký podíl každá částice má na duchu a životu, právě tak velký podíl má i na čití.“

Kap. V. — „De primo omnium in Mundo Motore, *Luce,* seu *Igne*: movente, fovente, formante et ornante, omnia.“ — K. cituje některé výroky o tom, že podstata světla zůstává filosofům hádankou.

Přece však sám pokouší se ji vysvětliti, an dí: „Prvotní světlo (prasvětlo) bylo ohromná spousta žhavého ohně z rozkazu Stvořitele v spoustě světové hmoty vzniceného, by učiněna byla viditelnou i na tvary dělitelnou i věčně pohyblivou, a tím by uvedena byla do věcí protiva, do světa však pořádek, rozmanitosť a věčná trvalosť.

Část světla v třetí den stvoření vnořena byla v zemi ku zdělání nerostův, část v den čtvrtý rozestřena po nebi a hvězdách, konečně v pátý a šestý den část uzavřena v těla živočichův, aby vše všude utvařovalo, zahřívalo a zachovávalo.“

Ku každé jednotlivosti v tomto výkladě chce K. přihlédnouti a spůsobem pak mathematickým podstatu světla dovoditi. I probírá slovo za slovem; aby pak účinky světla náležitě vysvětlil, dovozuje je z účinků ohně v krbu, jež podrobně vykládá, shrnuje pak na konec tyto účinky ve trojici, již tvoří *zřeďování* (rarefactio), *teplo* (calor) a *světlo* (lux). Seznajíce náležitě přirozenosť těchto účinkův, přijdeme tím také k poznání světla. Neboť jakož záleží na tom, by strom nebyl pozorován bez kořene a potok bez svého pramene, tak také účinky přírodní bez příčin přírodních.

Kap. VI. jedná „De innata rebus virtute, *Natura*: cujus vi fiunt, sunt et operantur omnia. Et quid sit aliquid *Naturale* dici.“

Všechna stvoření a každé jednotlivé mají sílu, by se ve svém bytí uchovala, a tudíž také zvětšovala a rozmnožovala. Sílu tu nazývají *přírodou* (natura), četnými epithety ji zdobíce. To vše pobízí k bedlivému uvažování a Komenský klade si otázky:

1. Co že příroda jest a co činí?
2. Odkud že má svou sílu?
3. Jakým že spůsobem ji uvádí v činnosť?

Definuje pak přírodu, jako vrozenou celému světu a každému ve světě tělesu sílu bytí, konání a spočinutí — sobě přiměřeného.*)

Následuje pak obšírný rozbor, odůvodňování a dokazování každé jednotlivé z těchto případností. — *Přirozeným* nazývá K. cokoli s námi se rodí, a cožkoli z podnětu přírody se stává.

„Přídavky“ k Fysice své zakončuje K. slovy:

„Některé věci týkající se jednotlivých dílů budou následovati na svých místech; toto vidělo se mi nyní místo poznámek k přehledu mé Fysiky přidati, by bylo jasno, že jen principy Mojžíšovy jsou pravými klíči ku přírodě, a jak pravou rozžatou pochodní mohou býti osvětleny všechny věci.“

Kdo přečetl si Komenského fysiku, dozná, že K. jeví se v ní hlavně tím, čím vždy a všude býti se přiznával, — *theologem.* V úctě neomezené sklání se před Písmem jako zdrojem poznání, a snahou jeho jest s Písmem uvésti v souhlas přírodozpyt. Při svých schopnostech neobyčejných a hlubokém vzdělání filosofickém poznával (a ve své činnosti učitelské a spisech didaktických dokazoval), že nejsprávnější, zvláště pro přírodozpyt, je casta, již razil Baco Verulamský, ukázav na důležitosť a nezbytnosť zkušenosti a názoru i na jediné oprávněnou methodu věd přírodních, indukci: avšak duch jeho (následkem vychování zajisté — mělť učitel jeho Alstedius naň vliv nemalý, — i následkem poměrů, v nichž žil,) klonil se vždy k mysticismu. Také ryzí jeho, z celé duše a plného přesvědčení plynoucí víra byla (jak soudíme) tomutu směru podporou.

Odtud vysvětlujeme si, proč snažil se přivésti svou filosofii přírody v souhlas s Písmem také i po stránce vnější. Zakládalť si nemálo na souhlasu trojice svých principů poznání i své trojice základů světa s Trojicí božskou. Také trojí jakosť podstatná a. p. naplňuje jej potěšením. Radosť jeho pak nad důkazem, že vše stvoření rozděluje se na *sedm* tříd nebo skupin, přechází (v „doslovu“) v nadšený jásot. To posvátné číslo sedm! Všude se jeví! Sedm planet, sedm dílů světa, sedm druhů meteorů, kovů a t. d., sedmero spřežení jakostí hmatových (viz str. 276.)

*) *Komenský* převádí tuto úkol „ducha“ na úkol „přírody“. Dle toho by měla se příroda s duchem stotožňovati, což přece zase K. popírá.

sedmero rozdílných chutí, sedmero tonů v hudbě a t. d. Nesrovnává-li se to s posvátnou sedmičkou v Písmě?! Sedm dní v témdni, sedm neděl od Velikonoc do Letnic, sedmý rok rokem sobotním (annus feriatus), a sedmkrát sedmý rokem jubilejním. „Proč to vše", táže se K. „ne-li, by vyjadřovalo obraz Boží, jehož sedm očí prochází veškerou zemí (Zach. 4, v. 10) a jehož sedm duchů jest v obezření trůnu jeho (Zjev. 1. v. 4.,) jenž sám s každým stupněm svého tvora mystickou doplňuje osmičku." — Odtud také lze si vysvětlovati, proč K. stavěl se proti některým vymoženostem své doby, (byli, jak svrchu poznali jsme odpůrcem Koprnikovým i Galileiho, a také proti Descartesovi vystoupil spisem cit. na str. 290), i proč duch jeho prozíravý, jenž předstihoval celá století, trval na názorech, které jižjiž se viklaly a dobou nejbližší jako bubliny byly smeteny. Připomínáme tu jen na př. názor K., že tíže je pohyb sympathie. A přece nepřekročil K. ještě svůj 51. rok, když spatřil Isák Newton světlo světa.

Ze stanoviska, na němž stojí „Fysika" Komenského, nebyl — toho nelze tajiti — rozvoj přírodních věd možný. A přece dílo toto, jež za dob Komenského bylo velmi ceněno, velebeno ba i básněmi oslavováno, jež zajisté bylo hledáno, když bylo čtyřikrát vytištěno, jemuž ještě dlouho po smrti spisovatelově dostávalo se velké chvály, je hodno také za našich dob uznání a povšimnutí bedlivějšího, než se mu při vydávání spisů K. dostává; nadobro pak nezasluhuje odmítání a zapomenutí.

Je to především Komenského snaha uvésti v souhlas vědu a víru, i spůsob, jak této harmonie se domáhá, jež zasluhují pozorného povšimnutí. Snaha ta nebyla ovšem nová. Avšak, kdežto předchůdci a někteří vrstevníci Komenského tento souhlas spatřovali v tom, že věda má se naprosto podříditi autoritě víry, a že Písmo svaté jest jediným zdrojem všeho poznání a vědění, K., jak viděli jsme, vedle Písma stavěl zkušenosť, jako ne-li rovnocenný, aspoň nezbytný zdroj poznání. Jemu zdařilo se také (a nelze toho podceňovati,) na základě jeho principů, tento souhlas víry s vědou provésti mnohem lépe a přesvědčivěji než všem jeho předchůdcům. Dedukce jeho plynou na tom základě přirozeně a bez násilnosti; jen málo je ve Fysice míst, kde pomáhá si poněkuď hledaným výkladem Písma, nebo kde důsledky

vedené z Písma nesouhlasí s praemissami na zkušenosti postavenými. Lze tvrditi, že tento spůsob přírodovědeckého bádání došel u Komenského svého vrcholu, ale tím také vlastního zakončení.

Byltť již v 17. věku spůsob ten blízko svému úpadku, a jen jednotnosť a úplné splynutí obou směrův, o nichž na počátku jsme se zmínili, zjednaly „Fysice" Komenského tolik chvály, a přívržencům mystiky dodaly nové posily. Této jednotnosti a tomu dokonalému splynutí různých směrův ve „Fysice" dlužno se tím více podivovati, ježto K. jeví se nám býti ve filosofii eklektikem. Vždyť sám praví v předmluvě „Fysiky", že všechny autory dlužno bráti v potaz (odst. 35.) a že od každého lze něco získati. A jen velký duch Komenského dovedl se látky tak zmocniti a tak ji „methodicky" spořádati, aby „různá mínění všech uvedena byla v souhlas". Než tato „methoda" nebyla v podstatě Baconovou methodou induktivní, pro niž, jak uvedeno, Komenský velmi horuje, ale jíž se přece jenom nepřidržuje. —

V eklekticismu Komenského však nelze nespatřovati také mírumilovného rysu jeho povahy. Míní, že odstraněny budou spory mezi spisovateli (odst. 35. předml.), uvedenali budou mínění jich v souhlas. Odstranění sporův a smír v bádání vědeckém — toť také jeden z účelů „Fysiky", jejímž však nejvyšším cílem jest pravda a jisté a neomylné poznání její. —

Toť jsou příčiny, pro něž „Fysika" Komenského nezasluhuje, by upadla v zapomenutí, a které jí zaručují trvale jistou cenu, i když nepřihlíží se k nemálo zajímavým názorům a poznámkám, jichž řadu velkou skytá. V té příčině zmiňujeme se opětně o jeho trojici principů světotvorných a jich vzájemném spojení a závislosti, zvláště pak o nauce o „duchu" jako oživovateli a udržovateli všeho tvorstva a každého jednotlivce. Ačkoli však duch zachovává jednotlivé rody, čteme přece také poznámku, že z nerostu může se vyvinouti rostlina (Fys. str. 129) a z rostliny zvíře. Poznámka jest interessantní tím, že upomíná na theorie descendenční, již přinesl teprve náš věk. Také nauka o jakostech, třeba ne zcela původní, zbudována je souvisle a zajímavě, a pod. m. v. Ovšem však jen „okem doby Komenského sluší na Fysiku patřiti", jak praví Zoubek (v I. vyd. Života J. A. Komenského), a s toho stanoviska ji také posuzovati.

ELEMENTS

OF

CHEMISTRY,

IN A

NEW SYSTEMATIC ORDER,

CONTAINING ALL THE

MODERN DISCOVERIES.

ILLUSTRATED WITH THIRTEEN COPPERPLATES.

BY MR LAVOISIER,

Member of the Academy of Sciences, Royal Society of Medicine, and Agricultural Society of Paris, of the Royal Society of London, and Philosophical Societies of Orleans, Bologna, Basil, Philadelphia, Haerlem, Manchester, &c. &c.

TRANSLATED FROM THE FRENCH,

BY ROBERT KERR, F.R. & A.SS.E.

Member of the Royal College of Surgeons, and Surgeon to the Orphan Hospital of Edinburgh.

EDINBURGH:

PRINTED FOR WILLIAM CREECH, AND SOLD IN LONDON BY G. G. AND J. J. ROBINSONS.

MDCCXC.

Offert au nom de la famille
de Lavoisier par M. De Chazelles.

ELEMENTS

TABLE OF SIMPLE SUBSTANCES.

Simple substances belonging to all the kingdoms of nature, which may be considered as the elements of bodies.

New Names.	*Correspondent old Names.*
Light	Light.
Caloric	Heat. Principle or element of heat. Fire. *Igneous fluid.* Matter of fire and of heat.
Oxygen	Dephlogisticated air. Empyreal air. Vital air, or Base of vital air.
Azote	Phlogisticated air or gas. Mephitis, or its base.
Hydrogen	Inflammable air or gas, or the base of inflammable air.

Oxydable and Acidifiable simple Substances not Metallic.

New Names.	*Correspondent old names.*
Sulphur	The same names.
Phosphorus	
Charcoal	
Muriatic radical	Still unknown.
Fluoric radical	
Boracic radical	

Oxydable and Acidifiable simple Metallic Bodies.

New Names.	*Correspondent Old Names.*
Antimony	Antimony.
Arsenic	Arsenic.
Bismuth	Bismuth.
Cobalt	Cobalt.
Copper	Copper.
Gold	Gold.
Iron	Iron.
Lead	Lead.
Manganese	Manganese.
Mercury	Mercury.
Molybdena	Molybdena.
Nickel	Nickel.
Platina	Platina.
Silver	Silver.
Tin	Tin.
Tungstein	Tungstein.
Zinc	Zinc.

Regulus of

Salifiable simple Earthy Substances.

New Names.	*Correspondent old Names.*
Lime	Chalk, calcareous earth. Quicklime.
Magnesia	Magnesia, base of Epsom salt. Calcined or caustic magnesia.
Barytes	Barytes, or heavy earth.
Argill	Clay, earth of alum.
Silex	Siliceous or vitrifiable earth.

3. FIRE AS A PHILOSOPHICAL AND ALCHEMICAL ARCHETYPE

3.1. Sources and effects of fire

Fire [9,41,44,95-99] was believed to have both heavenly and earthly origins: it is brought from the sky by lightning, and it lives in the underworld of volcanoes. Due to its ubiquitous nature and its association with both good and evil, fire has been (and in some places still is) worshipped by many peoples throughout civilization. Because of various psychological reasons, fire is considered to be a personified, animated or living power: it is red like human blood and warm like the human body, it shines brightly in the night and may have a form of "eternal life" or by constant rekindling can be made into a "perpetual fire". Masculine fire (principle *YANG* – light) is thought to fight from the center and to have the power to decompose what nature joined before while the feminine fire (principle *YIN* – shadow) attacks from the surface, is difficult to withhold, and often disappears as smoke. Fire was believed to extend throughout the celestial spheres and even time was thought to move in cycles (*'ekpyrosis', 'conflagratio')* involving a period of its destruction by fire during the cycle's involution and/or end. Fire has for all intents and purposes accompanied mankind's thoughts, beliefs and doings from the very beginning until toady's serious scientific treatises including the theory of chaos applied (e.g., the heat transfer and/or distribution conditioning Earth's weather) not forgetting its mystical but regarded basis, see Fig. 12.

The generation of fire, which would be unachievable without the aid of fire bores or saws, was also sometimes also perceived as a sexual act that imagines male and female firewood. Corresponding views were most probably pronounced among Aborigines and such a conceptual framework consequently influenced ideas of fire in the body of humans, especially of women, also as a center of sexual life. In archaic civilizations with sacral kings, the sacred perpetual fire (the so called state fire) of the residence and temples of the royal ancestors was believed to be a phallic symbol, and was said to be sacred for virgins, who were viewed as wives of the state fire. The extinguishing and rekindling of fire at the inauguration of a prince to kinghood points to the idea of a spirit of the princes within the state fire and also to the cyclical renewal of the state in the purifying act of fire, which signifies the beginning of a new era. According to some *Hermetic* and *Gnostic* doctrines it was thought that the soul emanated from the God, fell into the body casting its internal fire, and at death returned to its former home. Thus, it was believed that during cremation the soul is helped to separate from the body and continued its journey to the heavens by fire. Fire has duly become a mandatory part of almost all holy places.

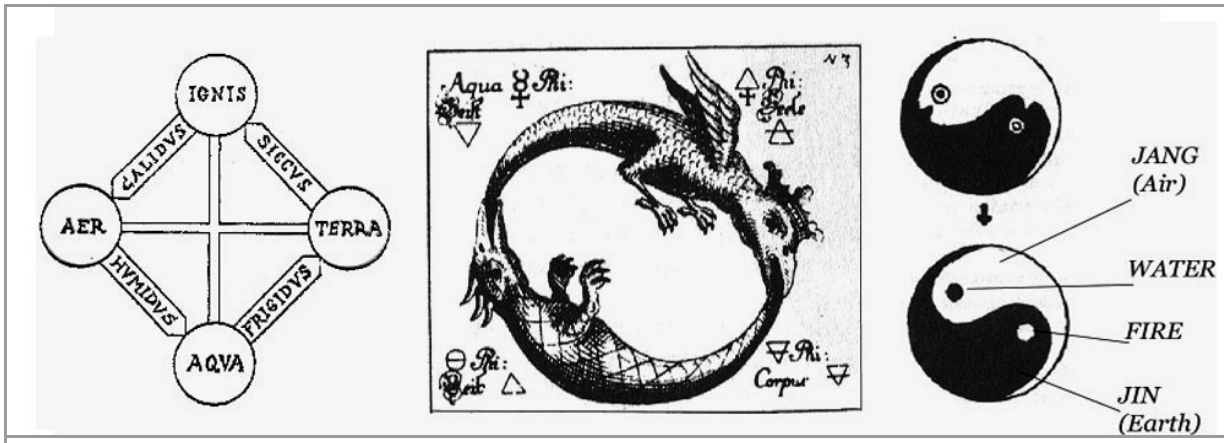

Fig. 12. – Partially oriented graph (left) illustrating various quantitative (circles) and qualitative (bars with arrows) connotations associated with the time-honored concept of the four-elements. In the middle, a loop consisting of two dragons (called 'Uruboros' eating each other tails) is revealed together with the symbols of the four elements in the corners. The upper dragon has wings to symbolize 'volatility' while the lower dragon has only legs to mark 'solidity'. The dragon and fish are mutually replaceable (right), and from two fishes similarly biting each other's tail the symbol of 'YIN – YANG' is created, which has had an important role in Chinese alchemy and philosophy

Burning, as a source of fire, is invisible. It is only the product of burning, i.e., *flame,* that is visible. The physical appearance of flame exhibits a surprising similarity for different substrates (fuels) and is scientifically reasoned to be a universal portrayal of conglomerated chemical reactions resulting in energy production in the form of heat and light, cf. previous Fig. 7. Flame propagation is explained by two theories: heat conduction and heat diffusion. In heat conduction, heat flows from the flame front, the area in a flame in which combustion occurs, to the inner cone, the area containing the unburned mixture of fuel and air. When the unburned mixture is heated to its ignition temperature, it combusts in the flame front, and heat from that reaction again flows to the inner cone, thus creating a cycle of self-propagation. In diffusion, a similar cycle begins when reactive molecules produced at the flame front diffuse into the inner cone and ignite the mixture. A mixture can support a flame only above some minimum and below some maximum percentage of fuel gas. These percentages are called the lower and upper limits of inflammability. Mixtures of natural gas and air, for example, will not propagate flame if the proportion of gas is less than about 5 percent or more than about 20 %.

At the beginning of science, however, flame was proclaimed to be just an optical illusion and only a visual specter that was felt not to have any substantial purpose – it illuminates and animates its surroundings, creating the illusion of liveliness. Fire can also create a vision of it being a living organism (*'agile' sive/i.e. 'ignis'*) that exhibits growth and change, and that has a need for food and air. Fire is composed of very sophisticated internal structures of flames, and shows continual instability, self-structuring and self-reproduction. Flame is the visible pattern of fire and was treated by any scientific, poetical and mystical

essays. There is a Latin proverb '*Ignis mutat res'* – 'fire changes things' (which is often exemplified by a burning candle; the more the wick is flaming the more is extinguished being buried in the melted wax thus feeding back the actual fuel supply). This saying implies that fire has the power to change the properties of matter, metals become ductile, raw food-stuffs can be transformed into a meal. Fire is the kindest servant and the fiercest master; an open log fire and its fireplace ('*focus')* is a symbol of the intimate asylum of the family home unit but, at the same time, is the source of potentially devastating danger and thus a focus of destruction. Fire is a source of expansion and contraction, annihilation and purification. The light of ideas reveals the truth, the glow of fire proofs its genuineness. Everything that flares up ends in ashes. Fire is self-destructing; its process of burning turns itself into a worthless thing. Fire is a fundamental beginning with its final effect being the entire end. Fire is often associated with chaos.

It is commonly pointed out that ancient people were familiar with four types of phenomena related to the glow that they associated with the ignition of fire. These sources were thought of as discharges of power: (i) lightning, which was earlier believed to be a sort of burning vapor, (ii) the way a torpedo fish stuns its prey (known to the early Egyptians and later recorded by Greek and Roman naturalists), (iii) St. Elmo's fire, which is the pale glow sometimes seen on the tips of pointed objects during stormy weather (again described by the ancient Romans in their military camps), and (iv) the tiny sparks associated with the curious property of attraction shown between pieces of rubbed amber and known as the amber affect (among the ancient Greeks amber became to be called '*electron'*, which was the name also given to the native silver-gold alloy that had a similar color as that of pale yellow sunlight). No connection between these four phenomena was made until comparatively modern times when we recognized and separated their thermal and electrical character, giving rise to the two basic scientific fields of thermal physics and electromagnetism. *Theophrastos* was known for defining the stone called '*lyncerium'* and for having observed and discussed both the amber effect and natural magnetic behavior.

Some writers give credit to *Thales*, who is known for his proposition that all things are indeed water and that its basic nature or cause is *'arche'*. Since that time onwards it is worth noting that the early 'natural myths' were slowly replaced by the thoughts and writings of ancient Greek philosophers [9,100-102], explanations that may be termed as being 'scientific'. Particularly in cosmology, two types of such explanations developed, one of which was theological in character and was referred to sometimes as 'organismic' because of its analogy with physical phenomena and the behavior of organism. For example, one such hypothesis concerning amber was that rubbing developed in it a certain "longing", a need that was satisfied by the amber 'catching' its "prey" by projecting arms, as do many living things (not too far from

understanding the behavior of caloricum). Another such explanation, known by The Greeks as the respective appellations of '*symphatia'* and '*antipathia',* was that all objects, both animate and inanimate, possess states of similarity or oppositeness. This means that all objects that are mutually in "sympathetic" would tend to unite or interact, whereas those in "antipathetic" or natural contrary to one another would exhibit the opposing tendency.

The second type explanation (as a physical explanation) is agreeable with the notion of fire, and may be termed as „materialistic" or „mechanistic". Its hypothesis was advanced in the Century following *Plato* by the Greek philosopher *Epicurus* (and based on the do of *Democritus*) who regarded the universe as consisting of two parts, matter and free space. He proposed that atoms move straight downward according to a natural tendency, supposing that the atoms that are falling through empty space collide by virtue of a self-determining power. This power causes an certain owing to which atoms can swerve a little from their vertical direction of fall. This deviation was termed '*parenclisis'* and enabled philosophers to explain the existence of objective chance and, also, of free will. This logic has had a direct impact on present-day thermal physics, in which we describe a system by a set of so called phenomenological qualities (e.g., temperature, pressure) that are not directly connected with the detailed microscopic structure of matter, but are manifested by directly measured values. Any such a system exhibits small spontaneous deflections from the predicted overall state that are called *fluctuations,* and that are caused by the particular tectonic-configuration of matter. Under standard conditions, fluctuations play a negligible role in most systems or, ate least, their effect is averaged. Only under certain circumstances do they become perceivable (often at the vicinity of bifurcations; a novel notion in the present day science) or even play a crucial function in the "spontaneity" of a system, a self-ordering commencement of the above mentioned "free will". The concept of the rotary movement of atoms led to the formation of innumerable worlds, separated from each other by empty inter-mondial spaces called *'metacosma'*. This was followed by the modern thesis of quantum uncertainty that is, in part, derived from the same roots. It, however, was rejected by some important physicists of the time who never accepted the probabilistic spirit of quantum mechanics and, instead, adhered to the *Democritean* access of the order of necessity ('*ananke').*

The term "*free will*" can lead to a confusing paradox because the only freedom that we have concerns the possibility to do what we wish but not necessarily the subject that we wish, best interpreted by the German philosopher *Schopenhauer* citing "*if I wish I could give away my property to the poor, but I cannot wish to wish"* later reformulated by *Barrow* [14] as "*no being can predict what he will do if he will not do what he predicts he will do*". It is related to *Chew's* formulation of the so-called '*bootstrap*' hypothesis (1970s) for a continuous dynamic transformation taking place within itself, which is mostly

related to the composition and interaction of sub-nuclear particles (the existence of each particle contributes to forces between it and other particles and these forces lead to a bound system in which each particles helps to generate other particles). It may even be said to be similar to *Marutana's* concept of '*autopiesis*' (i.e., self-making) [103] for a distinctive organization of (mostly living) systems (sharing the same Greek roots as the word '*poetry'* – creating). Autopiesis is used to analyze phase portraits or fractals within the framework of topology, which may appear similar to the action analysis of strongly interacting hadrons within the network of high-energy collisions, however, bootstrap does not form any desirable boundary as the living systems do.

3.2 Early Greek philosophical views

All nations of the world have their own mythology [100-102]. Myths, in the sense of the Greek term '*mythos'* that means speech (tale or story), bring poetic views of the world around us although customarily considered synonymous to something widely spread and not often true. For the Greek poet and philosopher *Hesiod,* the universe was a moral order close to the idea of an impersonal force controlling the universe and regulating its processes of change. The notion of *philosophy* that is joins images of fondness with knowledge (likely introduced by *Pythagoreans* and similar to the term *mathematical,* meaning conception or theorem '*mathema'*) came probably into existence when people were no longer satisfied with such supernatural and mythical explanations [104]. It proclaimed '*some are influenced by the love of wealth while others are blindly led on by the mad fever for power and domination, but the finest type of man gives himself up to discovering the meaning and purpose of life itself. He seeks to uncover the secrets of nature. This is the man I call a philosopher for although no man is completely wise in all respects, he can love wisdom as the key to nature's secrets'.*

The Greek word philosophy was actually derived from the notion of love ('*philia'),* which marked (or better explained) the attraction of different forms of matter, and of another opposing force called strife; hate (*'neikos'*) to account for separation. Love '*philia'* together with wisdom (*'sophia*'), factually composing the word philosophy, which first appeared first in the fifth Century BC and primarily concerned itself with the problem of "The One and the Many". Simply stated it involved the attempt to explain of the infinity of things we meet in the Universe (the Many) and the early Greeks believed that the single unifying thing (the One) can be some kind of a material substance, like water, stone or fire. They were concerned with finding an unchanging principle that lay behind all changes. The stable unchanging component of the Universe, which the Greeks called '*arche'* and living (and growing) nature was associated with the notion of *'physis '* (meaning nature as a procreative power).

People gradually began to suspect that there was a logical order in the universe and that humanity had the capacity to discover it. *Milesians* (birthplace

of the first cosmopolitan and "philosophical" ideas that eventually made possible the leisure-pursuit called *'schole'*) introduced the approach in which a single element, that contained its own principle of action or change, lay at the foundation of all physical reality. Its founder *Thales* was the first who tried to explain all things by the reduction to one simple principle, one *'arche'*. Such a single viewpoint is generally called *monism* and a more generalized approach, to see all things being alive, is '*hylozoism'*.

This new paradigm sees the world as an integrated whole rather than a dissociated collection of parts and it may also be called as an *ecological view*, if the term ecological (from Greek '*oikos'* – household*)* is used in a much broader sense, e.g., to see an engine not only as a functional whole, composed of parts, but also to perceive how the engine is embedded in its natural and social environment including its manufacturing (raw materials) or functioning (waste management). Today's science nearly always tries to reduce the complex world to as few principles as possible and the idea of reduction to a single principle is still alive. The physicist's search for the unified theories or, better, for theories of everything (i.e., looking for a data compression to achieve a particular interwove *'final'* theory) can serve as an illustration. On the other hand the Eastern sages have emphasized that the nature of our world cannot be reduced to a number of simple principles and any reduction inevitably leads to misinterpretation. They are aware of the complex interconnections of all aspects of nature and even of the connection of these aspects with our minds

In early times, the *Milesians* tried to explain things by the reduction to one simple principle (*'arche*') and by viewing everything from a single point (*'monism'*). *Anaximenes* introduced the important idea that differences in quality are caused by differences in quantity, citing "*when it is dilated so as to be rarer, it becomes fire; while winds, on the other hand, are condensed air. Clouds are formed from air by felting; and this, still further condensed, becomes water. Water, condensed still more, turns to earth; and when condensed as much as it can be, to stones".* On contrary the *Pythagorean School* was a more religious society that cultivated secrecy and speculated that power could be obtained through knowledge. They developed a theory that provides a form or limit (numbers) to the "unlimited", saying that things consist of numbers.

Numbers (*'arithmos*') were natural in character and represented bounds (*'peras'*) and their ratios were called *'logos'*. They thought that number was a unifying principle in the Universe, so that anything that could be numbered was ultimately linked to other things with the same number. Numbers had meanings apart from their relationships with other numbers. Thus, musical harmony was linked to the motion of the heavenly bodies. The discovery that there were numbers that could not be represented by fractions precipitated a crisis so deep that these numbers had to be called irrational numbers that lay beyond the arithmetic pattern of the Universe. In medicine, the *Pythagorean* saw the principle of harmony at work (body as a musical instrument). *Philolaos* began to

teach and lectured about a ‘central fire’ in the cosmos and located the home of the chief God *Zeus* there.

It was *Xenophanes*, a celebrated teacher in the *Pythagorean* School, who took the Gods of Greek mythology and, one-by-one, reduced them to certain ‘meterological’ phenomena, especially to clouds. God was, in his view, an immaterial eternal being, spherical in form, like a universe, and lots of modern believing scientists often understand God in this spirit, i.e., identifying God with something very abstract, with mathematical or physical principles of the universe.

Later *Zeno of Elea* introduced a proof of contradictions[1] using the term ‘*aporia’* and taught that space and time were immanent in our conceptions. It is also close to the notion ‘*parado*x’, which is a synthesis of two Greek words ‘*para*’ and ‘*doxos*’ meaning beyond a belief, and in its modern `counter-intuitive` findings throw often light upon something fundamental (such as the Maxwell’s demon giving the insight of intimate linking for the seemingly disparate concepts of entropy and information).

The concepts of space and time are not things as they were in themselves (*‘noumena’*) but rather our way of looking at things (*‘phenomena*’ – nowadays phenomenology). *Heraclitus* again redirected his attention to the change substituting dynamic *‘pyr’* – fire for the static *‘arche’* of the *Milesians.* He said that water, air and even ‘*apeiron’* are some substances or even material objects, but fire is the process or becoming. Fire cannot be static. It is not a „thing“. It is the primary form of reality. Fire itself exhibits the tension of opposites and, indeed, depends upon it. The world is an ever-living fire citing “*this world,*

[1*] Zeno’s customary arguing showed the famous story of Achilles who could not overtake the tortoise (having a prematurely start) because he must always reach the point that tortoise has passed so that logically the tortoise would always be ahead. The involved arguments implicate paradoxes against perpetual motion as well as against the multiplicity of length (later following the idea of a formal and skeptical rationality when bisecting a line, which swill always leave us with another segment that can itself be bisected, and so on, thus never reaching a single point, cf. Chapter 10, dealing with fractals). In the current viewpoint, however, it appears obvious that any non-denumerable infinity of points in a line is much larger than any infinity Zeno could have imagined and that the sum of infinite series of numbers, like convergent geometrical progression, is known to have a finite sum. In the past, the elucidation of Zeno’s paradoxes were contributed by such personalities as Newton, Leibnitz or Cantor but, recently, its apparent illogicality obtained a new meaning within the framework of quantum mechanics where the measurement itself affects the state of quantum system under observation. By the technique of a fast checking the decaying quantum system can be slowed down and even temporarily come to rest. Within this outlook, when the Heisenberg principle of limited distinguishability is applied for a finite length interval, Δx, the change of the associated impulse, Δp, may stretch to infinity due to the impact interference of measuring probe. In that case the Heisenberg product must be averaged, which means that we move from the configuration (quantum) space to the phase (mechanic) space of stochastic language, see the paragraph 7 dealing with the concept of quantum diffusion, Chapter 6.

which is the same for all, no one of the Gods or humans has made; but was ever, is now, and ever will be an ever living fire, with measures of it kindling, and measures going out". Neither the Gods, nor they, nor the souls of human beings could escape final destruction citing "*all things are an exchange for fire, and fire for all things, even as wares for gold and gold for wares. Fire lives the death of air, and air lives the death of fire; water lives the death of earth, earth that of water".*

The circular process was called *'ekpyrosis'*. *Heraclitus* taught that all changes in the world arise from the dynamic and cyclic interplay of opposites, and saw any pair of opposites as a unity or a whole. This unity he called *'logos'* which can be similarly applied to "awake people", those who could make themselves understood (as matter of interest – those who avoided public life of their city states *'polis'* were called strangers and were rated as second-rate citizens *'idios').* The existence of opposites depends only on the difference in direction of motion; the principle states that The Universe is in a state of flux and that all things are, at the same time, identical and non-identical assuming that the way up and down is indistinguishable. Here we can also cite the famous aphorism "*you cannot step twice into the same river".* The process of change is a process of opposites and diversity creates the problem of identity which is not self-evident, *''it is impossible for fire to consume its nourishment without at the same time giving back what it has consumed already. This presents a process of external exchange like that of gold for wares and wares for gold".* Fire was traditionally a part of limitless *'apeira'*, sacred and self-referenced *'apeiron'* (indifinite, boundless) primordial beginning – non-material subsistence. Fire (*'pyr' – flamma)* delivers light (~ eyesight), that is transmitted (~ hearing) by air *('aer'- flatus),* reflected (~ appetite) by water (*'hydor' – fluctus)* and absorbed (~ tactility) by earth *('ge'- moles)*.

It is part of myth that *Prometheus* stole the fire from *Zeus (*thought by *Platonians* to actually happen to the blacksmith *Hephaestus).* It is of interest that the word '*promethean*' is derived from the Sanskrit name for drill and can thus be understood as a personification of the act of making fire. *Oastanes* the teacher of *Demokritus* was aware that there existed a natural power (possibly fire in sense of energy) that can overcome all other powers and is, thus, capable of creating unification but also is ready to diminish it repeatedly. It, however, was not specified until speculation of some early Greek philosophers, notably *Empedokles,* who was apparently the first to name the four *basic elements* (cf.

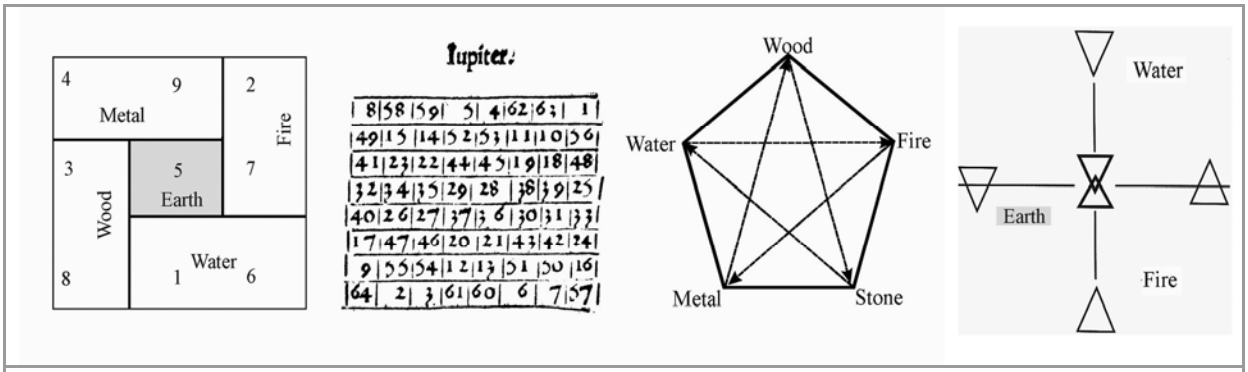

Fig. 13 – Left, the numerical symbolism, initially familiarized by the Chinese concept of figures, where the central number five represented the Earth (as the allied symbol for the great China). Though other elements bear the traditional character, the important behavior of particular number grouping was associated with the display of identical sums read for vertical, horizontal and diagonal recon. It can be extended to higher orders of numbers, and such squares became later popular in the Middle Ages as the subject of various mystical prognostic and magic periapt (middle), often specified to certain astrological terms, planets, etc. On the middle right, the early Indian concept of material elements is depicted showing clockwise (along the solid lines) the creation, which reveals along the dashed lines with arrows the destruction (symbolized, e.g., as the extinction of fire by the action of water). It is noteworthy, that this early scheme may emblematically account for the formation (water-to-wood) and annihilation (wood-to-fire) of life. Far right is the most traditional representation based on triangles where the vertical symbolizes the opposites: fire - our own self (faith) which should float up during our life, and water (our feeling, love, which should be spirited as seen from 'above'). If the spirit is treasured to achieve worship they became interpenetrated (middle overlapping triangles) and can reach attunemention (hexagon, see next Fig. 15.).

Fig.12 and 13.) that signified the substantiality from which all subsistence (or being) were composed.

In Greek, however, the elements are termed as '*stoicheia'* (today's chemical stoichiometry) and the entire name '*elementa'* (beginning) was authentically derived from LMN the first letters of the Etruscan (Phoenic) alphabet. The *Empedokles* concept of such four patterns/roots ('*rhizómata*') was, seventy years later, made widely known by *Aristotle* but it came together with the fifth platonian subsistence/being *'quinta essentia'* that was thought to interject a certain qualitative principle (*'arche'*). It was correspondingly conceptualized as the ether (*'aither')* – something celestial and indestructible (derived from *'aitho'* meaning glowing, flickering) possibly related to the Aristotelian "primeval matter" (*'prote hyle')* and interpreted as the presence of subjects. The four elements had been proposed gradually through the ideas of *Anaximenes* – air, *Xenophan* and *Parmenides* – earth and *Herakleitos* – fire, and he also emphasized that fire most completely reveals the "heavenly" reality of our universe, i.e., its order (*'kosmos'*). Sanctified fire gave a basis to the so called "Empedocles complex" where the love of fire is bound with its respect and the instinct of life with the perception of death [105,106].

Aristotle was concerned about the general forms and the cause of being (science of being as being), and discussed the notions of potentiality ('*dynamis*')

and actuality (*'entelecheia'*). He also proposed that elements determine not only the degree of warmth and moisture of a body but also their natural motion upwards and downwards according to the preponderance of air or earth. All things are in one way or another analyzable down to the basic bodies – fire tends to rise upwards and become air while water tends to fall downwards and become earth. All motions and all actions succeed in bringing into actuality what is potentially contained in the process of heat transfer such as evaporation and condensation. Mere potentiality without any actuality is the "prima materia" – existing nowhere by itself.

According to *Aristotle,* a body can only be moved if there is a mover in contact with it and if the mover communicates with the object by power involved in the movement (the first particles of air are moved first moving than other particles and finally moving the whole object). The power involved in the initial movement of a body decreases, however, in proportion to the distance moved, so that with time, the thrown body comes to a rest. This was taken for granted in almost every philosophy of nature until Newton's brilliant step to overcome this intuitive principle by the introduction of the dissipation of energy into the process of motion. *Aristotle's* consideration of the effect of heat led him to the conclusion that metals, glass and stones that melt on heating are composed of water, whereas materials that merely softened contain various amounts of earth – infusible stones are earthy. Similarly, liquids that did not solidify upon cooling were thought to contain a lot of air and those that readily solidified were supposed to compose mostly of water, and those that thicken were thought to contain more earth or more air. His written observation on "Generation and Corruption" describe flame as a burning of smoke, a claim which was retained by *Theoprastus* in his book "On Fire" but extended to recognize that fire can be generated in various ways and has three manifestations: *flame, burning charcoal* (in sense of glowing combustion) and *light.* It is interesting to remember one of *Theoprastu's* statements that if had the term moisture replaced by flammable volatiles would be an acceptable description for flaming combustion even today. For those times, *Theoprastus* gave a rather accurate account of the slaking of lime when he noted that quicklime evolved more heat when wetted that when left alone, and for the heat stored in the lime is analogous to the fuel required by lamps (note that if "heat" is replaced by "chemical energy" and "fuel" by a "liquid reactant" this statement still stands). Moreover he remarked that old quick-lime does not release as much heat as would new because time had reduced its energy through the contact with air, and that finely-grounded material evolved little heat because of its small particles (noting larger surface area in contact with the atmosphere). These remarkably acute observations not only show the quality of teaching at that time but also demonstrate that the foundation of todays's thermochemistry was laid as early as in the fourth Century BC by an implicit distinction of fire, flame and heat. The most significant contribution of *Theoprastus* was in his book "On Stones", in which

he not only gave the first classification of minerals (into metals, stones and earth) but revealed a rough form of thermal analysis used as an aid in identifying stones and earth, the latter can be identified with clay minerals, relying only on the five senses, not an easy task even for today's technology. It was written '*some stones can be melted while others cannot, some are combustible while others are not and, in the very process of combustion or, rather, of exposure to fire, stones exhibit many differences ... for earth indeed may undergo melting and if, as some maintain, glass is made from vitreous earth, so too it is firing that causes this earth to become glass'. Theoprastus* described the burning characteristics of certain stones, possibly lignite or bituminous shale, melting of asphalt, conversion of pitchstone to perlite, and the firing stone of Siphonos (possibly steatite) that is '*soft enough to be turned on the lathe and carved, but when it is dipped in oil and fired it becomes extremely dark and hard'.*

Later *Vitruvius* produced his practical treatise "De Architectura" curiously noting the phenomenon of a thermal gradient across the material '*when the sun is keen and over-bakes the top skin it makes it seem dry, while the interior of the brick is not dried ... bricks will be more fit for the use if they are made two years before ... to dry throughout'* . From the fact that larger stones floated on mercury whereas small droplets of gold sink, *Vitruvius* made a clear enunciation of the principle of specific gravity. Clearly the practical knowledge of the effects of fire/heat had progressed more in the time between *Theoprastos* and *Vitruvius* than it had in several centuries previously, as would indeed be expected in a highly civilized Rome that paid much attention to aesthetic aspects of life and to personal comfort, which required the use, creation or manipulation of fire and/or heat.

3.3 Concept of four elements

As already mentioned, it was Greek philosophers who played perhaps the most important role in the concept of fire trying to explain the attraction of different forms of matter introducing rather smart concept of opposing forces. *Empedocles* taught that originally all was 'The One'. All elements were held together in indistinguishable confusion by Love, while the force of Hate manifested itself as a separation of these elements. The four elements were kept in a 'sphere' of Love, while Hate surrounded the outside of the sphere. When Hate began to enter the sphere, Love was driven towards its center and the four elements were gradually separated from one another. The elements alone are everlasting, but the particular things we know are just unstable and temporary compounds of these elements. They are mortal because they have no substance of their own, their birth is a mixture and their death is their separation. He held fire as the rarest and most powerful compound of elements, which consumed the souls of all intellectuals, and which he thought was issued from a central fire, or the soul of the world.

Anaxagoras postulated a plurality of independent basic elements, which he called the seed (*'spermata'*) citing "*all things ('chremata') were together, infinite both in quantity and smallness; for the small too was unlimited. The science of all things was together, nothing was clear by reason of the smallness. For air and ether contained everything, both being unlimited. For these are the greatest items present in all things, both in quantity and in magnitude".* He thought that it was a mind, intelligence or pure reason *('nous')* that was the source of all motions as well as of the knowledge inherent within us. At the very beginning these seeds mixed without order but under the effect of a cosmic starter '*nous*' the non-arranged matter set itself into motion and began an orderly world '*cosmos*' that was created out of the initial chaos. In more recent times this idea has been a recurrence in '*deism'*, which is the belief in a God-architect, who, after creating The Universe, assumed no control over the created nature or their lives. Such a deity is often used as the explanation of operations of a supernatural cause, which became popular even among some believing scientists. *Plato* seemed to distinguish between fire and heat as well as *Aristotle* apparently differentiated temperature from the quantity similar to heat even though the same word ('*thermon*') was used for both. *Aristotle* and later philosophers paid attention to the notions of "*spirit, breath"* which by some were identified with ether and by others with fire that was always considered as a basic composition element. In Aristotle's view any substance is a composite of form ('*morphe')* and matter ('*hyle'*) originally meaning wood. Consequently this philosophical view was often called '*hylemorphism*' and it stated that matter without form cannot independently exist and so form cannot exist separately, which somehow rejects *Plato's* explanation of the universal Forms/Ideas as existing separately from individual things. He believed that things on the Earth move because they tend to reach their natural places and argued that, although heavenly bodies have eternal motion, there cannot be an infinite series of movers and, therefore, there must be one, the big Mover – the Architect in the series, who is unmoved.

Demokritos and his teacher *Leukippos* imagined immense worlds that resulted from the endless multiplicity of moving atoms. The soul consisted of the smallest and roundest atoms, which were more subtle and globular in shape and could be identified with atoms of fire. Sensation was due to atoms from outside knocking up against the soul-atoms. The first formulation of the principle of causality can be seen in the words "*No thing comes about in vain without cause but everything for a reason 'logos' and by necessity 'anake'." Democritos* introduced the hypothesis of images or idols '*eidola*' as a kind of emanation from external objects that made an impression on our senses. He believed in the shape

Fig. 14. – Choice of symbolic epitomes related to Alchemy shows (left) the allegoric pictures associated with the early edition of books related to Hermetic philosophy and alchemy. The middle figure illustrates the secrete position of alchemy as a lady-figure sitting on the thrown with her head touching the sky (blessed wisdom), holding in the left-hand a scepter (as a symbol of power) and carrying in the right hand one open and one closed book representing the unlocked and secret sides of learning. The ladder symbolizes patience necessary to pull off all the steps to achieve self-acknowledged epiphany (attainment of the state of "Big Masterpiece"). In the right picture, the hoodwinked figure illustrates the one who does not follow nature while the other, more appropriate one, is allowed to lionize the "Earth Interne – vitriol" following thus the rabbit, which is symbolizing 'prima materia'. The seven inherent steps are shown to go up, gradually climbing the mount, symbolizing the seven metals' tasks and aiming to the planetary Gods. After ascending the seven steps both principles (sulfur and mercury) are purified and, thus, are revealed as naked bodies, which symbolizes the desired state of 'Heavenly Mercurial' (Cabala 1616).

and related arrangements of elementary particles, and similarly to *Pythagoreans,* he distinguished notions for *'matter'* and *'form'* linked through a process of development. In contrast, *Plato* and *Aristotle* believed that form had no separate existence but was immanent in matter; their philosophy and scientific ideas dominated Western thoughts for two thousand years until a radical change was brought about by the new discoveries in physics, astronomy and mathematics (*Copernicus, Bruno, Galilee, Descartes, Bacon or Newton)* that viewed the world as a perfect machine governed by exact mathematics.

In the Greek interpretation (Fig. 12. and Fig. 13.) all material things are a different combination of elementary *fire, air, water and earth* held together by integrative and structural essence *ether* that was a heavenly and imperishable matter (which was thought to make up the universe of fixed stars and firmament). The four elements were not only plain mixtures (quantities) but arranged as a balance of four qualities: *hotness, coldness, humidity and dryness* that defined each element using the pairs of opposites (dry/hot, dry/wet, wet/cold and dry/cold). Hotness and coldness were active and the remaining two

were submissive (secondary passive) qualities. Properties associated with dominant (active) qualities had a tendency to grow if the object is surrounded by either a hot or cold environment. It was, in fact, the first sense of a *thermal process*. Due to the enormous vastness of these relationships graphical representations became very popular (cf. Figs. 12, 13 and 14.) and later it was even believed that the formal manipulation with graphical symbols can be helpful for the solution of particular problems (cf. however, modern theory of graphs).

The hypothetical structure of matter based on such a scheme brings about an important consequence – the potential or intrinsic "thermal" property of all existing substances. Thus, e.g. alcohol, gunpowder and pepper are intrinsically hot substances, continuously active in this sense also with respect to other bodies, while opium and snow are examples of intrinsically cold materials. Moreover, the antagonistic nature (so called '*contraria'*) of different Elements and Qualities ensures eternal changes and movements of all things in the universe. These changes are, however, not completely free, but are submitted to the remarkable principle of '*antiperistasis'* that controls the relationship between the two active Qualities – coldness and hotness. It can be formulated as follows: *The properties of any body which is bound up with coldness (hotness) tend to increase in the case where the body is surrounded by the hot (cold) environment*.

This principle akin to the modern *Le Chatelier – Braun* principle provided, in a lot of cases, correct qualitative predictions of the direction of thermal processes. We may quote *Oinipides of Chios* for a typical example consistent with the principle of antiperistasis: "*Water in a deep well show in winter the smallest degree of coldness, while in very hot days is extraordinarily cold*." Interestingly, this statement is actually valid and is not only a consequence of our subjective feelings, but it was confirmed also by careful hydrological studies.

Besides numerous successful applications of the principle of antiperistasis, there were also cases where it completely failed. One example of such failure is the dissolution of black gun-powder containing saltpetre, which, led contrary to expectation, does not warm up but instead cools down. Such exceptions were either neglected or, in better light, given an opportunity for discussion about other weak points of the doctrine. The most important problem, crucial for the theory, was the so-called problem of '*primum frigidum'*. While there was no doubt in which Element warmth dwells – of course in fire – the primary domain of coldness remained uncertain and, thus, made the conclusions of the theory not very plausible.

The later gathering of the vast practical experience with glass bowl thermometers resulted in the following of the '*peripatetical'* (i.e. Aristotelian) explanation of its function together with the above theory as a whole became rather diffident. Accordingly, the coldness in external air activates the hotness

inside the bulb which then is likely discharged into the wall of the bulb. This process changes the ratio between 'Qualities' of the enclosed air, in other words, it changes its 'Form'. This depleted form of air has obviously a smaller volume and the resulting empty space has to be immediately filled by water due to the '*horror vacui'* – nature's abhorrence of a vacuum.

In spite of this fact, the concept of temperature was superfluous for the general description of natural processes within the frame of Aristotle's theory; the term '*temperatura'* was frequently used by ancient physicians well before *Avicenna*. Their idea of temperature was in closely connected to the individual's temperament and was determined by the relative levels of four Qualities that were necessary to maintain the form of the tissues of the human body in a proper healthy state – homeostasis. But, in fact, these old physicians did not appear to care about how to determine this evidently crucial parameter.

Certainly, matter ('*materia*' – potentia pura) was not distinguished from energy ('*energie'* – actus) such that it was proposed that *when heating a metal one was simply adding more "fire"* to it. *Theophrastos* proposed three stages of fire: *glow, flame* and *lightening* while *Galenos* brought in the idea of four degrees for warming and cooling with a "neutral point": equal parts of ice and boiling water. These four degrees were still accepted by medieval alchemists and *Mylius* [107] proposed a classification according to the Sun passing through *Aries* (signifying calcination), *Cancer* (solution), *Libra* (sublimation) and *Capricornus* (fermentation). The highest degree of fire was *burning as vehement as fusion* and *each twice as great as the preceding degree.*

Comenius, a well-known Bohemian educational reformer and philosopher of Czech origin, progressed to distinguish three degrees of heat (*calor, fervor and ardor*) and cold (*frigus, algor* and one unnamed) with a reference to an ambient (normal) temperature (*tepor*). The highest thermal stage, called "*ardor*", represented an internal degradation, i.e., "*a combustible substance that collapses inwardly and is dispersed into atoms*". The unnamed coldest stage was noted as "*a freezing at which a substance breaks up by constriction in the same way as the heat of fire decomposes it by burning*". In this manner *Comenius* actually, although unwittingly and unknowingly, hinted at the present-day concept of absolute zero. He also stated [11] an almost modern definition of *thermal analysis,* (genially interpreted [44] by *Mackenzie*) as "…*to observe clearly the effect of heat and cold, let us take a visible subject and let us observe the changes that occur while heated or cooled, so that the effect of heat and cold are apparent to our senses...". Comenius* was also the first to observe the "non-equilibrium character" of such thermal treatment and analysis, noting [3] "*...by a well burning fire we can melt ice to water and heat it quickly to very hot water, but there is no means of converting hot water to ice quickly enough even when exposed to very intense frost..."*. It was an intuitive observation of the phenomenon now called latent heat, and possibly laid the foundation to the discipline of calorimetry.

3.4. Impact of alchemy

The history of fire cannot be complete without mentioning the subject of '*alchemy'* [108-111], a form of science that preceded, and arguably began, the more rigorous and modern discipline of chemistry [112]. The origin of the word alchemy is disputed and could be from the Arabic word '*al-kimijá'* – meaning treated by fire, the Hebrew word *'Ki mijah'* – meaning given by God, or the Greek word '*chemeia'* – meaning comprehension of wetness. The latter was also found in the writing of *Diocletian* as the art of making metal ingots and the term *´cheo´* means pouring or casting a liquid and *'chymeia'* means the art of extracting juices, herbal tinctures or generally saps in the sense of vitality. Also the current word 'chemistry' may be related to the Egyptian word '*kemet*' , which means 'black earth' or to something unknown but precious in relation to the Persian word *´khimia´*. Fire is even mentioned in the Christian teological lineage, e.g., the abbreviation INRI ('*Jesus Nazaretus Rex Judaeorum'*) was once interpreted as '*Igne Natura Renovatur Integra',* i.e., through fire Nature is restored to its wholeness.

It is not generally known that alchemy was later subdivided into *spagyrii,* the art of producing medicaments, dyes, ceramics, etc., (often trying to transform matter into algebraic combinations), *archemii,* which focused on the development of metallurgy and transmutations of metals, and *Hermetic philosophy* (often synonymous to alchemy itself, see Fig. 14.**),** which is a sanctuary of learning *('prisca theologia')* build upon performance (*'traductio'*), explanation ('*exegesis'*) and interpretation (*'hermeneusis'* – nowadays giving substructure for a modern interpretative hermeneutic description).

Behind the legendary seven Hermetic principles there lie aspects of early cosmology and a verbally bequeathed book known as '*Kybalion'.* Some of the inherent principles of alchemy are, indeed, reflected in modern terms and ideas of current physics, which is often criticized because alchemists certainly thought within completely different frames and measures. Nevertheless let us abbreviate some of them:

i) Principle of spirituality – The Universe is a spirit or belief, and was created simultaneously with many other universes – their origin and destruction occurring in a twinkling of an eye.
ii) Principle of similarity – what is above is also below, birth of universes and fundamental particles, creation of works of art.
iii) Principle of vibration – nothing is motionless, everything is in permanent move, vibration of matter is slow while vibration of mind is too fast to evoke stationary state, rhythm switch leads to qualitative changes.
iv) Principle of polarity – associates with vibrations, the higher the vibration, and the more positive the pole; everything has two faces, and it shows the

antagonisms of order and disorder, war and peace, day and night. From this an ethical edict there follows the transformation of hate to love.
v) Principle of rhythm – following the polarity as everything is oscillatory, coming up and away, breathing in and exhaling, arriving and leaving, inflowing and out flowing; circumambulatory come-and-go.
vi) Principle of causality – every action has its consequence, and coincidences do not exist but are the effect of an unknown law, people are subjected to a lawfully ordered universe.
vii) Principle of gender – sexuality is involved in everything, counterwork of masculinity (positive pole) and femininity (negative pole); process of generation, sexual energy in spiritual alchemy, God mate (often identified with the previous point iv).

Alchemy, however, prescribed to the idea of existence of a "first mover or God as creator" (Almighty, Deity) and believed in an evident order installed in the world. This argument, probably formulated by the Iranian prophet *Zoroaster,* was expressed in the form of the question: "*who could have created the heavens and stars, which could have made the four elements, except God?"*. In the Christian Europe the alchemy was similarly presented as '*donum Dei'* [113].

Hermetic learning might well have been ascribed to astrology by the *Hermes Trismegistos* but, later, it was extended to medicine and alchemy, where the obscure Byzantic *'Tabula Smaragdina'* [114] became a favorite source for even medieval alchemists. It contained seven famous principles, and from these scholars obtained knowledge of the laws of sympathy and antipathy by which the different parts of The Universe were related. Hermetism was extensively cultivated by the Arabs and through them it later reached, and consequently greatly influenced, the Western culture although often misinterpreted. Hermes' stick *'rhabdos'* was ornamented by two twisted snakes showing "waving water and blazing fire" as a unity of contradictions and thus becoming a symbol of life. In the present time it may be speculated that it resembles the double helix structure of DNA structure.

Although it is difficult to be certain of its origins, alchemy most likely emanated from China (as early as in the 8th Century BC and better inscribed by 144 BC in the connection with an enterprise older than metallurgy – medicine). Chinese practitioners of alchemy generally considered its ultimate objective to be the development of medical practice and not the generation of gold from base metal. Alchemy in China was all but destroyed when *Kublaj-chan* ordered the burning of the *Taoist* writings, thus destroying most alchemistic records (which included that of the earlest recipe for gunpowder). For a long period of time, it was believed that physical immortality could be achieved through the taking of

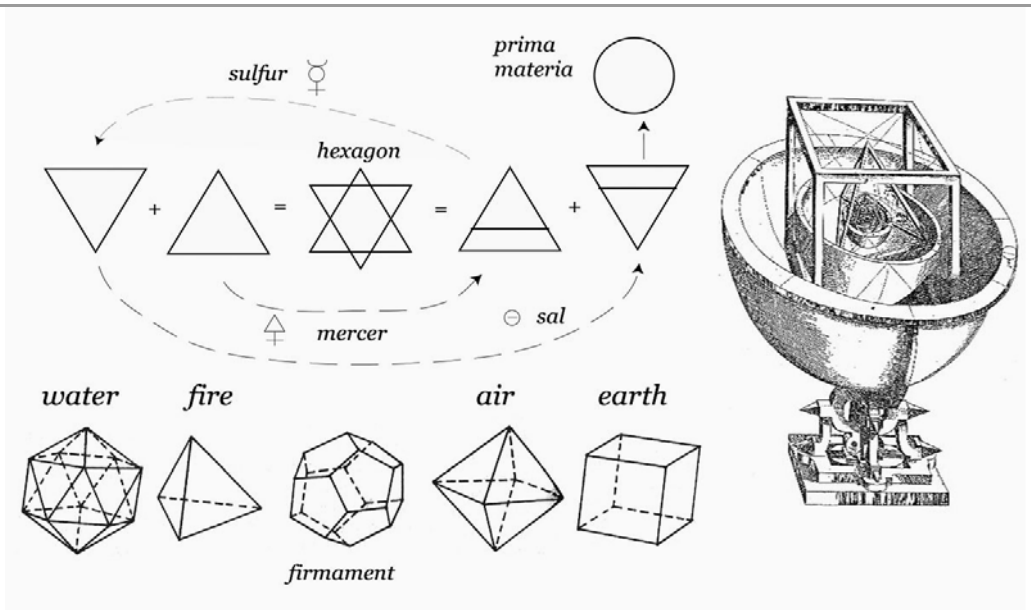

Fig. 15. – Symbols traditionally used for the depiction of the four elements, upper line shows the composition of the plane triangles while the lower line is made up of the explicit geometrical bodies. On the right, the geometrical model of an aggregated universe is revealed with the outermost sphere belonging to Saturn, and with Mercury and the Sun in the center. (The illustration is the imitation drawn after the Keppler's picture in his 'Mysterium Cosmographicum', printed in about 17th Century).

alchemical mixtures (drugs), an idea that probably vanished when the Chinese adopted *Buddhism*, which offered another, less dangerous avenue to immortality via meditation. This shift in belief left the literary manifestation of early Chinese alchemy embedded in the residual *Taoist* canons. One of the important but less well-known treatises was the book on therapy by nourishment [115] published in about 670 AD. It described the process of distillation was already described and the quality determination of distillates that could be accomplished by the process of freezing out.

However, the oldest known Chinese alchemical treatise is supposed to be the "Commentary on the *I Ching"*, which had an apocryphal interpretation of the 'classics of changes', and which was especially esteemed by the *Confucians* who related alchemy to the mystical mathematics of hexagrams (six-line figures used for divination). Ancient Chinese natural philosophy was thus based on a flat, square Earth with the centered Chinese empire surrounded by the eight trigrams as the symbol of The Universe [116]. There were five elements ('*wu hsing'*), Fig. 13., that were related by two complementary principles '*yin'* and '*yang'*. Mutual transformation of the five elements could, e.g., give the birth of metals from Earth, or change metal to water, because on a proper treatment metals can turn to the liquid state, etc.. The elements were mutually antagonistic because fire is extinguished by water and water is stopped by earthen dam, etc.. Yin represents the female principle (darkness, passivity) while Yang, as the male principle, is connected with light and energy. Even numbers were considered as Yin and odd numbers as Yang. Each number was associated with

one of the elements – the central number `five` exhibiting a crucial position. This number symbolized the Earth and, simultaneously, represented the most prominent position between the five geographical directions – the center (originally referring to the China mainland).

This approach has also qualified in the so called '*magic squares'* – a famous object of philosophical, alchemical or mystic speculations [116]. It is known as a square-shaped array of numbers (or even letters) exhibiting certain properties, i.e., the sum of the numbers in each row, column or diagonal being equal. Because of its conspicuous worth it was kept surreptitious until the Arabic alchemist *Jabir ibn Hayyan* refined it into a very detailed but complicated system in his 'Book of the balances'. A numerical value for basic properties was assigned to each letter of the Arabic alphabet. When a word for a substance was subsequently analyzed letter by letter, the numerical values of the letters determined its composition. For example lead was composed of the 11 outer qualities (3 parts of coldness and 8 parts of dryness) and 6 inner qualities (1 part of warmth and 5 parts of humidity), altogether 17 parts. If, in a similar manner, the qualities were summed up for gold then a somewhat insignificant difference between lead and gold was found, i.e., for gold also17 parts of 11 outers and 6 inners again, indicating that a proper alchemical treatment (transmutation) could change the nature of such 'interrelated' metals. It was certainly applicable to the given alphabet and thus could have been freely interpreted.

Later in *Agrippa's* and *Paracelsus'* medieval books, this magical application was rediscovered but using the squares that were constructed by the Islamic method (although no direct link was traced with Islamic sources). It appeared as a promising way to achieve novel discoveries of new relations between things and their properties. The myths of dignified numbers persisted in China until recently [117], which idea might be penetrating the denomination of the periodic table of the elements where the 'prime numbers' and 'numbers of symmetrical principle' are though to be the restrictive islands of the element stability.

Also in India there is evidence for alchemy in Buddhist text. Alchemy came to be associated with the rise of *Tantric* religious mysticism and was recorded in the writings of *"Rasaratnakara"* (in about the 8 Century AD) and ´Treatise on Metallic Preparations´ (~ 1100), which recognized *vitalism* ('animated atoms') and *dualism* ('love and hate' or 'action and reaction'). The earliest records from 500-300 BC already recorded that the theory of nature was parallel to the conception of rudiments ('*tejas*' – fire, *´vádžu´*- wind, air, *´ap´* – water, *´prthví`* – earth and *´akáša´* – wood) but without a more definite influence comparing the role of elements in other alchemical images. In *Theravada's* view there was a plurality of universe surrounded by water and mountains having three planes of *materia form* (physical body), of *desire* (mental body) and of

immateriality and/or formlessness (body of law). In practice, the Indians has begun to exploit metal reactions to the extent that they knew as many as seven metals (and already subdivided as five sorts of gold). They supposed that metals could be „killed“ (corroded) often to provide medicinal bases but not „resurrected“ as was the custom of later European alchemy.

However, the birthplace of known alchemy is arguably Egypt and the Greek God '*Hermes'* (identifiable with the Egyptian God '*Thoth')* , who is possibly represented as the alchemy father in the largely indecipherable *Emerald Tablet* of 150 BC (as a part of a larger book of the secrets of creation), which existed in both the Latin and Arabic manuscripts. The history of Western alchemy may go back to the beginning of the *Hellenistic* period and is represented by *Zosimos of Panopolis* (3rd Century AD) who focused on the idea of a substance called "tincture" that was capable to bring about an instantaneous and magical transformation. The earliest notable author of Western alchemy, designated by scholars with the name *Bolos of Mende*, was a Hellenized Egyptian who is often represented by his indefinable treatise called `Natural and Mystical Things` ('Physica kai mystica') that contains obscurely written recipes for dyeing and coloring as well as murky grounding of gold and silver.

The *testing* of materials was understood in a double sense: experimental and moral. Gold was considered noble because it resisted fire, humidity and being buried underground. Camphor, like sulfur, arsenic, and mercury belonged to the 'spirits' because it was volatile. Glass was assumed to be a metal because it could be melted, a property associated with the seven known metals. The 13th Century AD pseudo-epigraphic book on chemistry, known as `Synopsis of faultlessness` ('Summa perfectionis'), contained the terms alcohol (older meaning of powder), alkali, borax or elixir and also suggested that metals were compound bodies made up of a mixture of mercury and sulfur. It recognized '*prima materia'* (first matter) as being a *fixative* (visible and solid – earth, represented by sulfur), *quintessence* (personification – salt) and *evanescentive* (implicit, hidden – air, represented by mercury). It was characterized by triangles that pointed up (escaping) or down (falling), cf. Fig. 15.

It was close to the Platonian geometrization that represents fire as a tetrahedron, air as an octahedron, water as icosahedra[2]* and earth as a

[2]* It is clear that life on the Earth depends on the unusual structure and anomalous nature of liquid water. Its small embryos of four molecules tend to come together to form water bicyclo-octamers which may cluster further to cyclic pentamers expanding to somehow curious network of ordered icosaheda (as foretold by Plato), which are in a certain dynamical equilibrium with its collapsed, but more frequent form a more symmetrical dodecahedra. The solid, denser form of water is the hexagonal ice and has a structure that is uncanonical with respect to the 'pentagonal-like' symmetry of a solidifying liquid that contains a high number of nuclei of icosahedra and dodecahedra. It may help to explain the curiosity why warmer water freezes more rapidly than cold water. It is because the cold water at the temperature near freezing is densely packed with these, for the ice incommensurable nuclei, which are thus capable of easier and thus deeper undercooling. The water at higher temperatures

hexahedron (cf. Fig. 15). By analogy it was also ascribed to show spheres of Mars, Earth, Venus and Mercury with the Sun in the center. Dodecahedron was assumed to play a role of the fundamental structure of firmament. Identification of elements with certain geometrical bodies led, however, to mechanization and mere ab-
straction of four elements was not thought to be clear enough for the need of alchemist's teaching so that it was supplemented by additional three (imaginary) principles: *sulphur* (as representing combustibility), *mercury* (as fusibility and ductility) and *salt* (as durability).

In the Middle Ages, European alchemy was chiefly practiced by Spanish and English monks (namely *Bacon* and conceivably also by the Christian mystic *Lulla*), who were seeking to discover a substance more perfect than gold (philosopher's stone) as well as a potable gold (elixir of life). Worth noting is Swiss/German *Paracelsus* who remarked that it is the human body that is the best of all 'alchemists' as it is capable of transmuting food into a variety of vital compounds. He also tried to understand alchemy as a kind of art. He highlighted the mystifying 'alkahest' as a universal medicament and he stated four pillars of medicine: *philosophy* (knowledge about nature), *astronomy* (knowledge of the macro-cosms), *alchemy* (in the terms of *Spagirii* as production of medicaments) and *virtue* (honesty of physicians). He held that the elements of compound bodies were salt, mercury and sulfur representing earth, water and air, respectively. He is also thought to be responsible for reintroducing the term alcohol from Arabic '*al-kuhl'* (originally meaning fine powder, Greek '*xérion*') as an early medicament otherwise known as '*tincture*', which he thought was a cure for everything. The Bohemian alchemist *Rodovsky* depicted alcohol as '*aquam vitae'*, a medicinal elixir that is best obtained by a procedure involving 14 repeated distillations of wine and the addition of 15 various herbs. It provided more real grounds to the mystical world '*elixir*' (from Arabic '*al-iksír'* meaning gemstone).

Fire was regarded as imponderable or nonmaterial and alchemists used heat lavishly and most of their illustrations include some indication of fire, furnace or a symbol of sulfur. Despite the crudity of the above-mentioned degrees of heat, alchemists laid more emphasis on an accurate temperature control of furnaces (*Norton* [118]) necessary in early metallurgy (*Agricola* [119], cf. Fig. 16.). Adjustment of temperature was, however, purely manual, oil lamps with adjustable wicks, water and sand bathes for lower temperatures and variation of fuels for higher temperatures. In various processes, such as firing ceramics or melting glass, it was vital to keep certain temperatures constant. This required the introduction of early scales for experimental practice.

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gradually disintegrate them possessing thus a greater number of smaller fragments, which can survive rapid cooling being more easily compatible with the highly symmetrical configuration of ice.

Moreover, fuels giving moist or dry heats were distinguished with an awareness of how to produce high

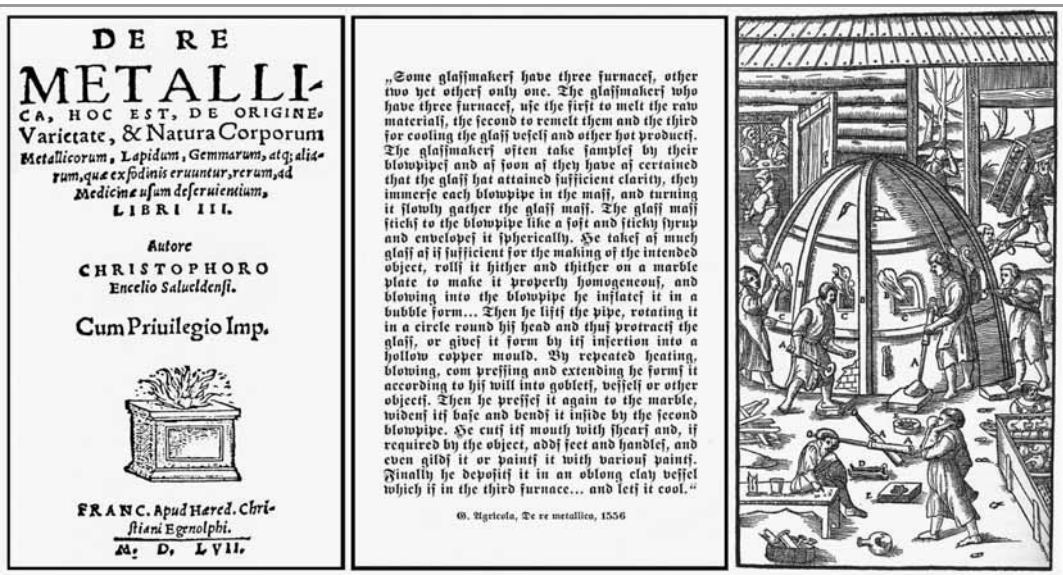

DE RE
METALLI-
CA, HOC EST, DE ORIGINE,
Varietate, & Natura Corporum
Metallicorum, Lapidum, Gemmarum, atq; aliarum, quæ ex fodinis eruuntur, rerum, ad
Medicinæ usum deseruientium,
LIBRI III.
Autore
CHRISTOPHORO
Encelio Saluelden si.
Cum Priuilegio Imp.
FRANC. Apud Hæred. Christiani Egenolphi.
M. D. LVII.
„Some glassmakers have three furnaces, other two yet others only one. The glassmakers who have three furnaces, use the first to melt the raw materials, the second to remelt them and the third for cooling the glass vessels and other hot products. The glassmakers often take samples by their blowpipes and as soon as they have as certained that the glass hat attained sufficient clarity, they immerse each blowpipe in the mass, and turning it slowly gather the glass mass. The glass mass sticks to the blowpipe like a soft and sticky syrup and envelopes it spherically. He takes as much glass as is sufficient for the making of the intended object, rolls it hither and thither on a marble plate to make it properly homogeneous, and blowing into the blowpipe he inflates it in a bubble form... Then he lifts the pipe, rotating it in a circle round his head and thus protracts the glass, or gives it form by its insertion into a hollow copper mould. By repeated heating, blowing, com pressing and extending he forms it according to his will into goblets, vessels or other objects. Then he presses it again to the marble, widens its base and bends it inside by the second blowpipe. He cuts its mouth with shears and, if required by the object, adds feet and handles, and even gilds it or paints it with various paints. Finally he deposits it in an oblong clay vessel which is in the third furnace... and lets it cool."
G. Agricola, De re metallica, 1556

Fig. 16. – Reproduction of the title page (front prolegomenon) from the very influential book "De re Metallice". Additional two selected (inside) pages (right) describe the process of processing glass and illustrate the period furnace with glass pipe-blowing custom. Note there a smart way of drying the fuel wood by pushing it around the furnace wall that enabled the minimization of humidity and thus achieving the wood higher caloric value

temperatures (also used in burning glasses and mirrors). They also accumulated a vast store of knowledge of the effects of heat on various substances, even if they were unable to interpret the results and satisfactorily measure the temperature.

The most celebrated process was calcinations, i.e., firing substances to turn into powder known as '*kalk*' or '*calx*' sometimes called '*alcool*' (of gold). The calcinations furnaces were customary named '*athanor*' (from Arabic '*at-tannur'*) when sand in a bath was replaced by ashes.

While Arabs had only weak acids, European alchemists of the 16th Century learned to prepare and condense strong acids like *`aqua fortis`* (nitric acid) and spirits of salt or *`vitriol`* (hydrochloric and sulfuric acids), their mixtures capable of dissolving even gold. They became a powerful instrument that made it possible to produce and also characterize ever more varied salts and their spiritual parts separated by distillation enabling to create a more exacting relationship between the identity and way of its testing. An unidentified element, often termed as *`alcahes`t* (i.e., *'alkali-est'* in the sense of a universal solvent resembling today's action of catalysts) was believed to exist as grounds of the four basic possibly to act as an all-purpose medicine.

At the turn of the seventeenths Century, alchemy flourished remarkably during the region of the Bohemian emperor *Rudolph II* and Prague became a home of many famous alchemists, among others there were *Hajek* or *Rodovsky*

of Czech origin as well as noteworthy *Stolcius* and *Marcus Marci* (cf. Fig. 17.). They wrote for that time very advanced books [120,121], which possibly foreshadowed some laws (such as the refraction laws of light and intuitively moved thoughts toward coming within reach of the conservation laws). *Marci*, however, was strongly convinced that white light was the simplest element (*'quinta essentia'*), which, interestingly, was close to the subsequent concept of 'elementary waves' propounded about fifty years later by *Huygens* in the wave theory of the basis of light. There, however, is inconsistent information about *Marci`s* educational activity, he was possibly rector of the famous Charles University, which was founded 1348 in Prague as the first university in the middle Europe. There, perhaps, a world first specialization called "*chimiatrie"* was unveiled, which was conceivably taught as an unusual subject with regards the traditional university disciplines: major '*artes liberales'* and minor '*artes mechanicae'* (i.e., learning common crafts such as warfare, see-voyage, business, agriculture, hunting, medicine or veterinary) but not in '*artes incertae'* (which was a part of the habitually rejected '*equivocal arts'* associated with occultism, which traditionally involved alchemy).

However, medieval learning is difficult to recapitulate in a condensed form but even in the contemporary world, full of progressive technologies, this elderly philosophy has retained its incomputable role. It remained engaged in the challenge of trying to maintain a sustainable world, on both levels of matter and mind, for the next generations. *Popper* recently recalled '*Tria Principia'* of cosmic evolution grades pointing out three internal appearances of the Universe: (i) a world of physical contradictions (challenge, personal precariousness – *´sal´*), (ii) a world of significance (implication, subjective experience – *´sulfur´*) and (iii) a world of energy (vivacity, creation of the human mind and ingenuity – *´mercer´*). It is somehow related to the interdicted and almost forgotten Hermetic philosophy, with prophecy (God) having the highest, and matter (Earth) the lowest state of eternal vibrations, everything there undergoing processes of dissolution ('*solve*'), and integration ('*coagule*') within three levels: (i) exploitation of raw materials or digesting of food on a physical level (life), (ii) breathing, energetically based on a spiritual level (love), and (iii) meditation, thought based on a heavenly level (wisdom).

3.5. Emerging new ideas

The modern scientific world is far beyond using any mystic concepts, and many areas of research are now public property [42,122-126]. Early mystical philosophy did not really need exact science. It did not look for measurable quantities and therefore scholarly knowledge was deliberately kept a secret often for moral reasons. The human mind, however, needs a bit of both. Hermetic philosophy admitted that the universe is calculable, separating quality and quantity at the same time, i.e., harmony is best when sensually perceived but

when expressed by numbers. Measurement was thought to be associated with the con-

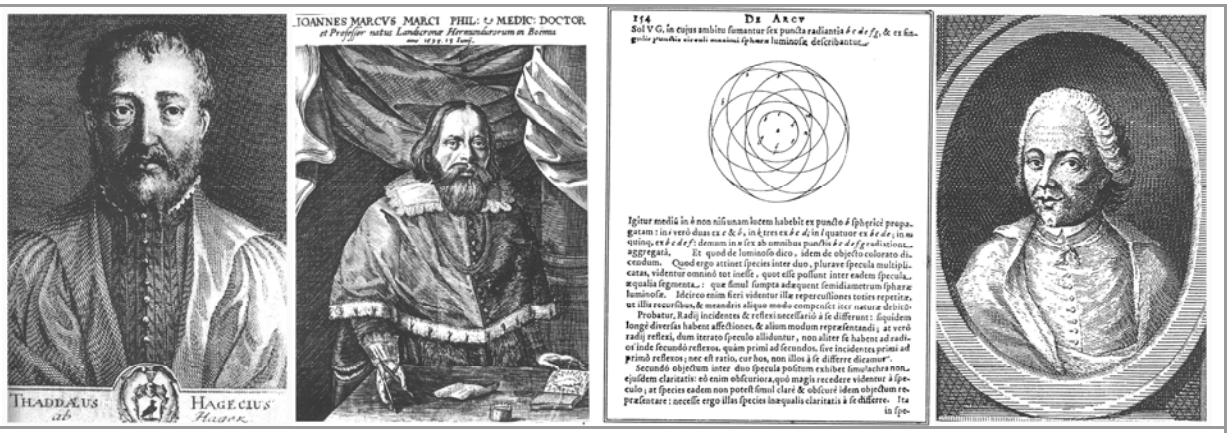


Fig. 17. – Some famous scholars from the Middle Age Bohemia: (left) *Tadeáš Hájek z Hájků* (1525-1600) known as Thaddaeus Hagecius ab Hagek , author of many books (geodesy, botanic, medicine) particularly acknowledged for the first concise book on the beer-making ´De cerevisia´ (brewery 1585), who became famous as a doctor of the *Rudolph II* (1552-1612, Rome Emperor and Bohemian King) during the flourishing period of alchemy in Prague. (middle left:) *Jan Marek Marků* (1595-1667) known as Ioannes Marcus Marci who probably helped to reveal the fundamental properties of the spectral colors that emerge when light passes through glass prism already aware of their monochromatic properties, i.e., any succeeding refraction or reflection did not change colors. He also studied the color change in rays when spectral colors are mixed. He passed light through a glass prism twisted into the form of a bracelet, which he called the 'trigonum armillare'. He pondered on the diffusion of light in circular spheres, and the way in which the intensity of the light diminished with increasing distance from the source, but only to a certain, terminal distance. He, however, was strongly convinced that white light was the simplest element, the 'quinta essentia'. Interestingly, his ideas were close to the subsequent concept of 'elementary waves' propounded about fifty years later by Huygens in the wave theory of the basis of light. (middle right:) Facsimile of the page 154 of his book 'Thaumantias liber de arcu coelesti' (right) explicates the Marci's two-dimensional model of the propagation of light spheres from a spherical source: on a circle with center (a) he chooses six regularly distributed point designated with the letters (b – g). From these points (as it were centers) he draws circles of the same diameter as a picture of the spheres of propagating light. The points of intersection the circles designated by (h – n) indicate the increasing intensity of the light in the direction of its source, and the set of light spheres is closed in an 'envelope'. (right:) *Prokop Diviš* (1698-1765) known as Wenceslau Procopius Diviss Bohemus from Pram a famous inventor of lightening rod (1754) and investigator of electrostatic effects.

sciousness of the person who actually makes it, but nowadays it comes close to the ideas of quantum mechanics. *Bohr* said "*there does not exist a quantitative world, there exists an abstract description of quantum physics. The task of physics is not a search how nature is, but what we can say about nature."*

As pointed out in the preceding chapters, fire was always kept in a central position of human awareness, in its view as a primary element. It was well-known that the orderly employment of fire provides warmth and pleasant conditions in which to think about, e.g., how to order things or how to gain easy

energy. Wild fire was feared to destroy everything, creating chaos by means of the destruction of material possessions held by society, as well as in terms of the destruction of the human mind. Fire leaves a fingerprint in all types of evolution! Let us again, briefly, mention alchemy, as an example of an old endeavor for fire. Within the modern world of science, alchemy is considered to be rather archaic and without a real scientific base, often subjected to ironical comments. We, however, should recall that alchemical philosophy was close to the science of Causation's; it tried to perfect matter whilst being aware of nature as a model. That is to say, it respected the order of nature, somehow resembling present day thoughts on living nature (ecology). Alchemy was undoubtedly related with the process of self-recognition, and success in the laboratory led to individualization, and, *vice versa,* individuality guided laboratory mastery. Alchemy was a universal art of vital chemistry, which by fermenting the human spirit purified and finally dissolved itself into a kind of philosophy. On the other hand chemistry, as a consequently derived true science of facts, is primarily oriented to the utilization of nature, freely processing and exploiting basic/raw materials and trying to dominate nature – it shamelessly enforces order on nature and neglects its consequences.

Paradoxically, perhaps, it was a mystic (*Agrippa, Meyer, Stolcius, Paracelsus*) and practicing (*Agricola, Valentinus, Rodovsky, Sendziwoj, Libavius*) alchemists who really believed in the physical transmutation of metals and not the theoreticians who contributed most to the scientific progress during the medieval alchemical area [126]. The allegorical complexity of alchemical notations and the impossibility of knowing whether the author understood what he was writing, or merely had copied a text that was obscure to him, made alchemists the butt of criticism and mockery. Thereby, its rationalization of chemistry and its marginalization of acculturation aspects are inseparable from the invention of easily available and distributable forms of written messages. The role of printing in alchemy is commonly neglected although crucial. As and could thus be confronted and challenged by more modern authors still full soon as ancient texts were published they become accessible to the wider public of various allegoric depictions. In 1597, *Libavius* published a book about fire (*'Pyronomia*,) where he already enhanced the associated role of human skillfulness and proficiency. However, it was *Helmont* (epigone of *Paracelsus)* who, at the turn of seventeenth Century, rejected the persisting theory of four elements, as well as that of the three primary bodies. Instead he believed water to be the unique primordial substance, and looked for two sources of natural development
of minerals and metals ('*seminal spirit'*), which were responsible for creating all objects in various shapes. He distinguished a kind of 'universal' gas from liquefied vapors, even identifying '*spiritus silvestris'* (CO_2) that he found emerged from certain natural substances when consumed by fire. In the book "*Sceptical*

Chymist" (1661), *Boyle* extended the attack on the theory of the four elements and planted the modern roots for natural sciences and the concept of chemical

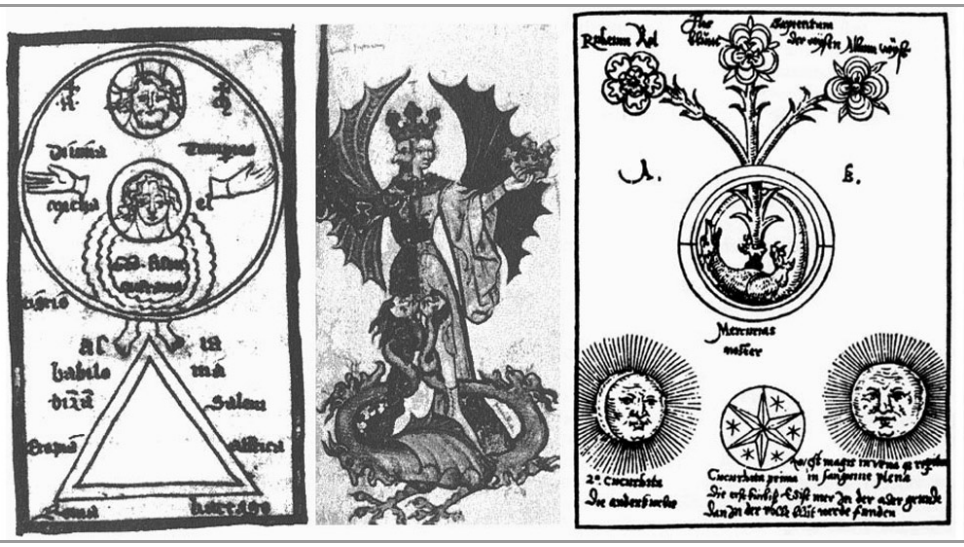


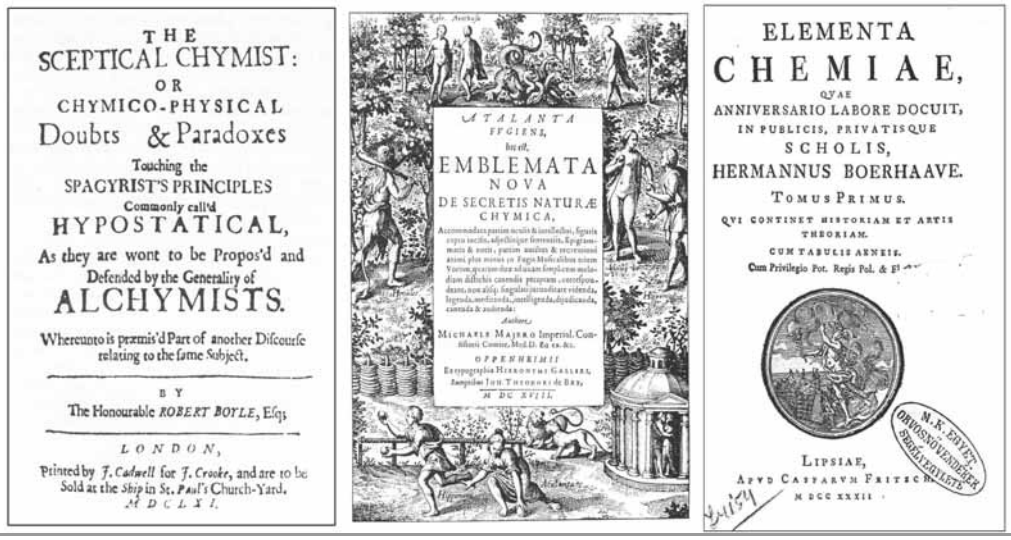
Fig. 18. – Symbolist use [9], for example, triangle (left) symbolizing both the Earth as well as fire (with its corner pointing up). It may be read in such a way that water and earth would be freed by fire out from 'prima materia' and transformed to 'kvitesency' symbolized by a superposed circle (about 14th cent). Middle: the demonic 'Hermafroid' stands on a dragon (symbolizing 'prima materia'). Masculine part holds sword (justice) while feminine holds crown (boast). It is noteworthy that this replicated picture is from about the 15th Century and is supposed to be a part of a gift from the Franciscans to emperor *Zikmund* at the occasion of the Constancy council that condemned the famous Bohemian scholar and reformatory priest, *Jan Hus* to the stake. At the right, notice inside the Hermetic egg, the laying 'Uruboros' speared to three flowers – golden, silver and central blue (which was assumed to be the Magian's flower – 'flos sapientum'), which was later assigned as the reassignment of Romaniticsm (Pandora 1588). Courtasy of *Helmut Gebelein*, München, Germany.

elements. The associated salt theory, which originally subverted the idea of a salt as an alchemic principle, helped in the understanding of the phenomena of solubility as a process. It became, correlatively, a way of further separating salts that finally helped *Lavoisier* to arrive at the modern definition of *affinities*.

It is worth noting that *Plato* already possessed a similar view of an element based on '*chóra'* (analogous to Indian *'amah'* that is understood to become fire or water containing '*proté hylé')*, i.e., continuous dynamic transformation of elements within themselves (resembling a quantum vacuum in the framework of bootstrap and/or particle democracy. The four elements were then identified with the macroscopic phases of gas (from the Dutch contortion of the Greek world *'chaos'*) and Latin derived liquid and solid. Fire became comprehended as heat and recently even better related to plasma, which accentuated and furthered thinking in the direction of yet other forms of energy that lie outside the aims of this book (e.g. nuclear).

Boyle was also known to strongly criticize the traditional, so-called "dry way separation". He pointed out that when compounds were put into a fire that

was ‘too hot’, the substances obtained were not necessarily components of them but were “creatures of fire” that revealed nothing about the original compound (products what experimenters call “artifacts” today). He preferred slow agitation and gentle heat that could have time to transform textures and therefore produce elements different than those produced from other methods of forcible decomposition. *Boyle* was also the first to use flame testing, probably the first *thermo-chemical analysis,* making it possible to recognize a substance by the color of its flame when it is burned as well as the property of evolved air called “elasticity” (its volume being inversely proportional to the pressure).


THE
SCEPTICAL CHYMIST:
OR
CHYMICO-PHYSICAL
Doubts & Paradoxes
Touching the
SPAGYRIST'S PRINCIPLES
Commonly call'd
HYPOSTATICAL,
As they are wont to be Propos'd and
Defended by the Generality of
ALCHYMISTS.
Whereunto is præmis'd Part of another Discourse
relating to the same Subject.
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NOVA
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CHYMICA,
ELEMENTA
CHEMIAE,
QVAE
ANNIVERSARIO LABORE DOCUIT,
IN PUBLICIS, PRIVATISQUE
SCHOLIS,
HERMANNUS BOERHAAVE.
TOMUS PRIMUS.
QVI CONTINET HISTORIAM ET ARTIS
THEORIAM.
CUM TABULIS AENEIS.
Cum Privilegio Pot. Regis Pol. & El
LIPSIAE,
APVD CASPARVM FRITSCH.
M DCC XXXII.

Fig. 19 – Title pages of some selected books that took a significant role in the gradual but lifelong maturity of an educational attempt to improve the learning of chemistry: (upper raw) from the yet alchemy-effected book by *Boyle* (1661) and *Majero* (1618) to the early chemical textbook by *Boerhaave* (1732).

Although the 17th Century was a time of notable scientific progress, the scientists of the day were themselves far less respected and far less listened to than today’s scientists. Some of them, such as *Newton* and *Leibniz* who are responsible for the introduction of many modern theories*,* were also devoted alchemists. The idea of “*fire fluid*” (globular particles that attach easily only to combustible objects) persisted for another two hundred years and assumed that when a substance is burnt, the non-substantial essence (‘*terra pinguis’)* escapes. The definition of the laws of conservation needed more precision on account of the action of traditional ‘*vital* and *mortal’* forces. Conservation was assumed to be something general between and within the system as probably first noted by the non-cited Czech educator *Marcus Marci* [121].

Descartes [127] played an important role, even though he first believed that The Universe is filled with matter in three forms: fire (Sun), transparent matter (Heaven) and dark matter (the Earth). All observable effects in nature were assumed to happen due to the eternal movements of matter, which form gigantic or quite small whirls – *tourbillons*. Such a theory can, of course, explain

everything, but unfortunately cannot predict anything. A little better was the theory proposed by *Gassendi*, a devoted follower of *Democritos*, who identified heat and coldness with microscopic material particles, adjoining atoms. Accordingly, the substance heat consists of spherical and very fast atoms, while the atoms of coldness are lazy tetrahedrons with sharp edges causing pain and destroying solid materials. The compatibility of this "substantial" theory with mathematical treatments probably helped it to survive with minor changes until the 19th Century. Interestingly, the premise of *Bacon* and *Descartes* that heat is a kind of motion, contradicting the opinion of *Gassendi* that heat consists of particles (`quasi-particles`) was unified, in a sense, by the modern kinetic theory of matter.

Some associations of the above mentioned ideas can be observed latterly in the symbolic lessons of Amerinindians within their innate principles, for example, the magic number 'four' representing world cardinal points, four traditional elements, four animal legs, etc. Indians used to evoke magical circularity of shapes like cone-shaped tent (tepee or wigwam) or rounded stone because the nature provides globular forms (sun and moon), living creatures sustain the rounded appearance without corners showing thus the harmony of nature and being. The circle is also kept as a symbol of human belonging each other (while sitting around a balefire when the Indian chibouk moves from hand to hand in support of peace). On the other hand, the implanted world of whites was assumed to be represented by squares like buildings, rooms, banknotes, televisions or computers, which used to make Indians feeling sad and so getting sicken of modernizing civilization. Indians grumble whites that their actions were not in the vital conformity with long-established wildlife, producing too much of unnecessary wastes harming thus the nature and producing disharmony for future generations. On the other hand, Indians tried to live within the rules traditionally given by the natural world as, for example, they hunted bison not only for food but they used almost everything to the last piece while the whites came to schoot bison just for chosen meet and pleasure of killing.

4. CONCEPT OF HEAT IN THE RENAISSANCE AND NEW AGE

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4.1. Phlogiston – deciphering combustion

The various phenomena of combustion [52,128-134] were known for many centuries before any attempt was made to explain them or, indeed, before any attempt was made to investigate them. One of the *Boyle's* contemporaries, *Mayow* assumed that atmospheric air contained a substance which he termed *'spiritus igno aereus'* which combined with metals to form '*calces'* and which was associated with the process of respiration. This assumption contained the germ of discovery of the new approach to explain combustion later enriched by *Becher* who assumed that all inorganic substances consist of three 'earths': the mercurial, the vitreous and the combustible. The last term was named as '*terra pinquis'* and when any substance was burned, this essence escaped.

Stahl gave to us a special characteristic of chemistry called the "blend union" or the '*mixt'*, which was distinguishable from aggregations (mechanical unions), and their analysis became the entire task of the chemist alone. It was later proposed that a mechanical agent or "instrument", i.e., fire (or heat), water (solvent) or air, bridged the gap between the '*mixt*' and aggregates. Fire put the *`phlogiston`* (renamed *`terra pinquis`*) in motion, air blew off the most volatile parts and water put the parts into solvated motion. Fire was therefore the instrument, and the phlogiston was the element entering into the composition of the `mixts`. It explained combustion as well as the transformation of '*calx'* into metal and, *vice versa,* (i.e., metal = calx + phlog.). Phlogiston was, thus, a revolutionary element since it suggested that both combustion and corrosion aide in the same operation of *oxidation,* which is the inverse operation of the process now called *reduction.*

During the so called '*phlogistic*' period (lasting for about one hundred and twenty years) the science of thermochemistry was enriched by the labors of many eminent investigators, e.g., *Cavendish, Pristley, Scheele.* Although it is easy for modern scientists to ridicule the absurdities of such a phlogistic theory, it must be borne in mind that this idea was very much contributory to the better understanding of early views of energy conservation and it served to stimulate a vast amount of experimental research. The downfall of this theory was caused by the observed fact that products of combustion retained a greater weight (mass) than the combustible substances from which they were derived. The ingenious attempt to explain this phenomenon by assuming that *phlogiston* possessed a negative weight did not, however, survive later rational protests. The final overthrow of this idea may be thought as the marking of the beginning of a new era that began modern chemistry but, the phlogistic period should also

be associated with the discovery of the more important constituents of the atmosphere (dephlogisticated air – oxygen, inflammable air – nitrogen, fixed air – CO_2, phlogisticated air – hydrogen and compound nature of water).

The true attacks on phlogiston would become significant only in a larger context when the theory of gases arrived, which was essentially developed by the work of *Lavoisier*. The key factor in his theory was the new substance of heat or matter of fire, called *caloric,* which crept in among the constituent parts of a substance and gave it expansibility. If the physical state of body were explained by the quantity of caloric, then consequently air would lose its essential function as a principle. Although caloric differed from phlogiston because it could be measured with an apparatus called a *calorimeter* (designed by *Wilcke* and later used by *Laplace, Lavoisier* and others), it was nevertheless an imponderable element with its own properties.

The belief that the elastic properties of gases could be accounted for by supposing that gas particles were stationary and subject of mutually repulsive forces was wholly Newtonian approach and it was readily acknowledged by most of 80s and 19s Century writers. It was related to the *Principia* where *Newton* had shown how Boyle's Law could be predicted on such basis if it was assumed that the repulsive force between any two adjacent particles of gas expanding or contracting isothermally was inversely proportional to the distance between them.

In 1977 *Lavoisier* expounded his view that gases and vapors resulted from combination of 'matter of fire' and with a 'base' which could be either a liquid or other volatile solid. The mechanism of this combination he resembled that of a normal chemical union. Heating occurred in the process of combustion, for example, simply because the base of 'air vital' (oxygen) had a greater affinity for the inflammable substances than for the matter of fire and so combined with it, allowing the fire to escape and became free. When fire was combined with ordinary matter it was undetectable, and it was only when it was free that it affected the thermometer and produced the sensation of heat. He defined the true measure of hotness simply as the quantity of free (uncombined) fire in a body.

Some year's later Irish chemist *Higgins* described fire as 'elastic fluid' whose elasticity was the result of repulsion, which was attributed to the 'charges of the repellant (fiery) matter' which formed 'distinct atmospheres' round the 'grosser parts' and so caused them 'to recede from each other contrary to their inherent and incessant attractive power'. *Higgens* went even so far that the density of the atmospheres varied 'reciprocally as the distances from the central particles, in a duplicate or higher ratio'.

Boerhaaves's description of fire in his *Elements of Chemistry* [54] showed that it was composed of particles, which were the smallest and most solid of all bodies yet known, and were also weightless, a fundamental property

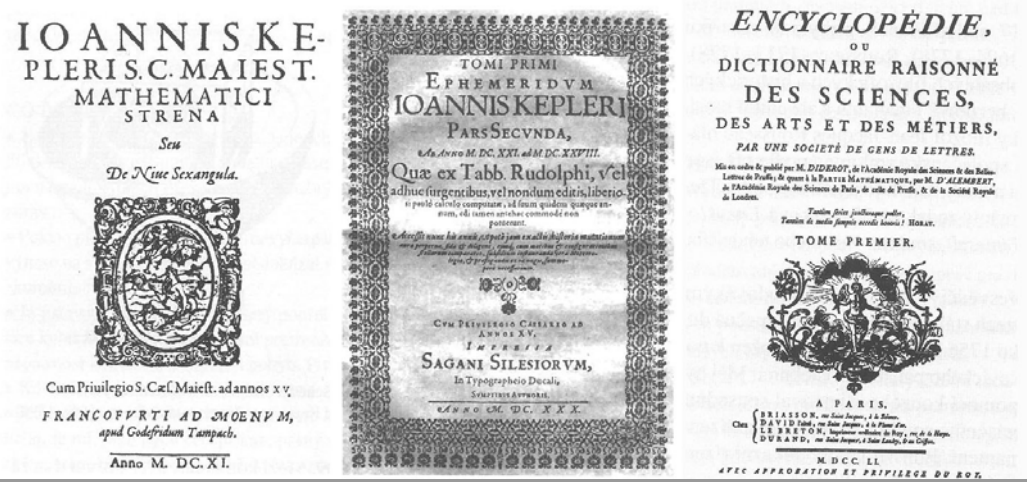

Fig. 20. – Less known book by *Kepler* "Strena seu de nive sexanguka" (1619) known as 'Christmas gift or about hexagonal snow' and (right) the front page of the famous 'French encyclopedia' (1751), which first dealt concisely with natural sciences.

for the later formulation of caloric theory. In his opinion it was the motion of particles of ordinary matter (conceived as a vibration) which was responsible for the phenomena of heat and it was the function of fire, by its own movement, simply to cause and sustain this motion. *Boerhaave*`s fire, both in its function and structure, resembled *Descartes'* subtle fluid rather more closely than it did *Lavoisier's* caloric. Indeed, it seems that belief in the materiality of fire was a part of standard doctrine, especially among chemists, long before *Lavoisier* received his sanction for the caloric theory.

4.2. Rise of the theory of caloric

By the time caloric theory emerged [134] there were already a number of well developed theories of electricity, magnetism and light that were based on the existence of subtle elastic and often imponderable fluids with properties remarkably similar to those of caloric. For example *Franklin's* description of electricity in the late 1740s conceived it as being composed of small weightless particles which, although being mutually repulsive, were attracted by the 'particles of common matter'. All bodies were though to contain a certain quantity of such electric fluid, even when they were electrically neutral, becoming charged only when an excess or deficiency of fluid was created. By the 1770s the fluid theories of electricity and magnetism were well known and generally accepted.

Unfortunately, the great pioneers, *Irvine* and *Black*, published almost nothing in their own lifetimes [133] and their attitudes were mostly reconstructed from contemporary comments and essays published after their death. *Irvine* supposed that heat was absorbed by a body during melting or vaporization simply because at the melting or boiling points sudden changes took place in the

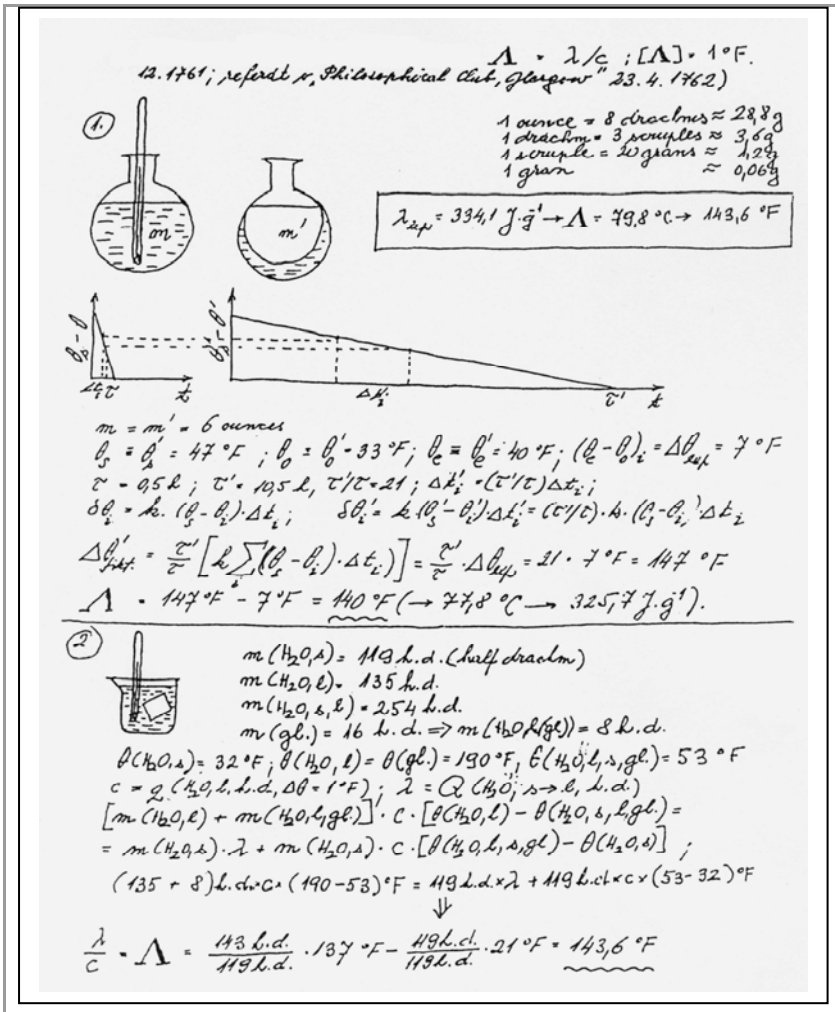

Fig. 21. – Recreation of Black's method [9] for the measurements of latent heat of ice melting, λ, (upper 1), was a special set up that was luckily made according to advice of a practical whisky distiller, citing "*when his furnace was in good order, he could tell to a pint, the quantity of liquor that he would get in an hour*". So that *Black* made his experiment in such a way "*boiling off small quantities of water and found that it was accomplished in times very nearly proportional to the quantities, even although the fire was sensibly irregular*". It described an almost linear change of temperature (θ) with time, which is probably the first record of thermal analysis. An allied calculation, according to Black's laboratory notes, is the incorporated and correct value of λ as revealed in the frame (in the relation to temperature increase of Λ = λ/c). Below (2) is shown the principle of Black's method for determining of latent heat of water melting, already using a kind of mixing calorimetry. He concluded "*I imagined that during the boiling, heat is absorbed by the water, and enters into the composition of the vapor produced from it, in the same manner as it is absorbed by ice in melting, and enters into the composition of the produced water. And as the ostensible effect of the heat, in this last case, consists not in warming the surrounding bodies, but in rendering the ice fluid, so in the case of boiling, the heat absorbed does not warm surrounding bodies, but converts the water into vapor. In both cases, considered as the cause of warmth, we do not perceive its presence, it is concealed, or latent, and I gave it the name of 'latent heat'.* (Courtesy of *Ivo Proks*, Bratislava, Slovakia).

ability of the body to contain heat. *Irvine's* account that the relative quantities of heat contained in equal weights of different substances at any given temperature (i.e., their 'absolute heats') were proportional to their 'capacities' at that temperature. It is worth noting that the term 'capacity' was used by both *Irvine* and *Black* to indicate specific heats, cf. Fig. 21. They introduced the term 'latent heat' which meant the absorption of heat as the consequence of the change of state.

In the calculation of the latent heat of a given mass of ice, *Irvine* took the quantity of heat that would raise the temperature of the same mass of water by 140 ^{o}F and the values for the specific heats of ice and water were thus 0.9 and 1.0 respectively. Where the melting point was x^{o}F above the assumed 'absolute zero' it followed from Irvine's assumption that the total quantities of heat in the ice before melting and the water after the change of the state, both quantities being measured at 32 ^{o}F, were proportional to 0.9x and 1.0x respectively and hence, on the assumption that heat had been conserved, that x = 0.9x + 140 = 1400 so that the zero point in this calculation would therefore be -1368 ^{o}F, the value being very sensitive to the assumed figure of specific heats of ice, later corrected to 0.85. *Lavoisier* and *Laplace* were careful to emphasize that small errors in the specific heats could seriously affect the calculation having also little sympathy for such basic `Irvinist` assumptions as the proportionality between capacities of various bodies and the quantities of heat that they contained.

Similarly *Dalton* [133,135] chose to consider the expansion of air at constant pressure between 55 and 212 ^{o}F (the range of his own experiments) assuming a proportionality between the total heat content that would have increased from Q_{55} to Q_{212} and the change of inter-particle force from F_{55} to F_{212}, i.e., $Q_{55}/Q_{212} = F_{55}/F_{212}$. By further relating F to the distance, d, between the particle centers, where d^3 were, of course, proportional to the volumes that the air would have occupied at given temperatures it followed that $d_{55}/d_{212} = T_{55}/T_{212}$ providing an estimate of absolute zero at -1515 ^{o}F. In 1801 *Dalton* mentioned "…*this remarkable fact that all elastic fluids expand the same quantity in the same circumstances, plainly shrews that the expansion depends solely upon heat; whereas the expansion in solid and liquid bodies seems to depend upon an adjustment of the two opposite forces of heat and chemical affinity, the one a constant force in the same temperature, the other a variable one, according to the nature of the body; hence the unequal expansion of such bodies…"*

An important approach was introduced by *Cleghorn*, who in 1779 related the material theory of heat in his book '*De igne'* as follows: "…*since the quantity of fire distributed among bodies increases with the attraction for fire that the bodies exert and decreases with the repulsion between the fire particles themselves, it follows that if in any body the former quantity is diminished or the latter increased, then the fire will flow from that body until equilibrium is again restored. Heat is then said to be generated. On the other hand, if the attraction of any body were to be increased or if the repulsion between the fire particles were diminished, more fire would flow into the body and in this case cold is said to be generated…"*

Like *Dalton, Avogadro* believed that gases were composed of particles of ponderable matter each surrounded by a sphere of caloric that was retained by an attractive force between it and the particle. It was this force, he maintained, which determined the quantity of caloric in any given molecules and he thus

differed from *Dalton*, for whom the quantity of caloric was the same in all molecules under similar conditions of temperature and pressure, irrespective of the nature of the gas and the magnitude of the force. The size of a gas molecule was determined by its chemical structure, and here gain *Avogadro* differed. So *Avogadro`s* view of gas structure provided him a new and virtually unique tool for the development of caloric theory. *Avogadro* was evidently assuming a close analogy between the mechanisms that retained caloric round a molecule and that which, according to *Berthellet* [136], governed the chemical combination between substances. He even proposed a purely empirical relation involving refractive power (rp) and the affinity for caloric (A), such as: rp = 0.419 A + 0.581 (A)1/2 and he devised a scale of the affinities of all compounds to vary from 1.3 to 2.49. Between these limits he laid the affinities of certain acids and alkalis, true neutrality being at 1.7

The greatest benefit of caloric theory was that it supplied an obvious solution to the problem of thermal expansion and contraction. Heating a body had the effect of adding fluid caloric to it and, consequently, the body expanded. On cooling the opposite occurred, involving the removal of fluid caloric from the body. Many of the properties of heat were explained by considering each particle to be surrounded by an atmosphere of caloric, whose density is related to the intensity of the gravitational attraction between it and the center of any particle. The gravitational attraction was considered to be inversely proportional to the square of the distance between the centers of the particles involved, while the caloric atmosphere, which caused the repulsion, was assumed to obey a logarithmic law in the analogy to the Earth's atmosphere. In liquids, the caloric content was sufficiently high so that the atoms were not held in a rigid position by mutual gravitational attraction and in gas this attraction was considered negligible. Thus, it was predicted that the expansion of a gas would be much greater than that of a liquid and than that of a solid. It also explained that the expansion coefficient increased with temperature more rapidly for liquids than for solids. In certain views on the physical behavior of gases, particles were even assumed to be stationary, the pressure keeping them such and being derived from the tension of caloric.

The theory of caloric played probably a similar role in making the observation that gravitational force does not pull all things together to form one very dense body as a current dispute about the invisible dark matter (and/or energy), which hypothesis is used to explain its yet undefined antigravitational forces that keeps the Universe expanding instead of only contracting under the omnipresent gravity.

A careful distinction, however, was drawn between the intensity of heat and the quantity of heat [133,134]. All atoms did not have identical caloric atmospheres, and although they all had a logarithmic dependence of caloric density on distance, the rate at which the atmospheric density reduced, varied from substance to substance. The quantity of heat required to produce a given

change of temperature for a given amount of material, was called the specific heat of a materials, by analogy to the term of ‘specific gravity’. Heat could take two different forms, sensible and latent. Caloric was considered to combine with atoms in a fashion similar to how atoms bind together, and with such combinations the caloric changed from its sensible form and became latent. Such a chemical combination of an atom with caloric produced a ‘new’ compound in which neither the original atom nor the caloric retained its identity. No heat was considered to be lost in the process since it was reversible – cooling a body down returned the caloric back to its sensible form.

Let us consider two erstwhile examples; when a piece of iron is compressed by hammering, the sensible caloric is squeezed out and the surface of the iron becomes hot, or if a gas is compressed it emits caloric and becomes hotter. It was thought that sensible caloric could be squeezed from a body by artificially pushing the constituent atoms into closer proximity to one another than what the mutual repulsion of their caloric atmospheres would allow. Therefore, if pressure was put on a substance near its boiling point, some of the sensible caloric would be lost from the substance and a higher temperature would have to be applied before sufficient caloric was available to the atom for a vaporization to occur. The less caloric a body had, the greater was the attraction between the atoms of that body and its surrounding caloric fluid. In adding the caloric to one end of an iron bar, the atoms at the heated end required more caloric than their neighbors and by having more, their attraction for this caloric were less. Thus, the neighboring atoms attracted the caloric away and continued to do so until all the atoms of the substance had achieved the same caloric at atmospheres. The facility with which caloric could be passed from one atom to another depended upon the structure and composition of the iron (substance). It is worth noting that a more careful study of what is currently being taught and used as the world quantity of heat concerning its behavior and phenomena shows a striking similarity with the above-discussed caloric theory of the past

There was another important account by assuming the *Berthollet`s* analogy between the behavior of caloric and that of acids, which allowed certain additional simplification. Thus it was no longer necessary to ascribe special properties to each of the forms of caloric. The latent heat and temperature changes was thus viewed as the result of opposition to the naturally expansive force of caloric in ponderable matter and it was the force of cohesion between the molecules which resisted this expansion force and so caused heating when caloric was added. *Berthellet* said in 1803 *“…If one hesitates to regard this similarity between the properties of caloric and those of a substance entering into chemical combination as a conclusive proof of caloric`s materiality, one cannot but agree that the hypothesis that it exists presents no difficulties and has the advantage of involving only general and consistent principles in the explanation of phenomena…”.*

4.3. Decline of the caloric concept

The weakening of caloric theory begin with the work of *Fourier* on heat conduction and with *Joule's* work of the early 1850s, which gave a trivial corollary of the equivalence of heat and work that, however, yet needed to determine the type of motion that was thought to constitute heat. Such uncertainty [136] was felt concerning the nature of the motion of heat and the process by which the matter was resolved was slower and far more complex than is suggested in most histories of that period. There was an interesting approach by *Rankine* (1850) to interpret the new thermodynamic principles in terms of an elaborate vortex model of the atom, the motion in this case being associated with an `elastic atmosphere` that revolved or oscillated about the `nucleus or central point` of any atom of matter. The quantity of heat was thus nothing more than the *vis viva* of the revolutions or oscillations perfumed by these atmospheres. Some years later (1867) another vortex theory was proposed by *Thompson,* who suggested that the atoms might be nothing more than centers of vortex motion in all-pervading fluid ether.

Already in the year 1812 *Davy* said [135] "…*The immediate cause of the phenomena of heat is motion, and the laws of the communication of motion…temperature may be conceived to depend upon the velocities of the vibration; increase of capacity of motion being performed in greater space; and the diminution of temperature during the conversion of solids into fluids or gases, may be explained on the idea of the loss of vibration motion, in consequence of the revolution of particles around their axes..."*

Rumford wanted to prove that heat has no mass and that it can be produced, without limitation, by friction. He also wanted to show that thermal motion of particles occurs also in liquids. He tried to explain heat transfer in a vacuum by the vibration of material particles that cause a 'wave motion of the ether', capable of propagating in a vacuum. *Rumford's* ideas contradicted the accepted understanding of such a heat transfer, which was thought to be the consequence of repulsion of the caloric particles in its 'non-ideal' solution, their high tension tending to 'redistilled' caloric through a vacuum from a warmer to a colder body.

Probably the turning point was the *Clausius*` explanation (1857) in which he gave a lucid and most lucid and convincing account of various motions – rotational, vibration and translational – of which he believed the molecules of solids and liquids to be capable. He argued that the observed specific heats of gases could only be predicted theoretically by taking account not only by the translation *vis viva* of the gas molecules but also their rotational *vis viva*. He also introduced the concept of the mean free path of gas molecules and he used to explain the slowness with which the gases were known to diffuse through one another. It was left for *Maxwell* in 1859 to add the ingredients of our modern

kinetic theory that was most obviously lacking in *Clausiu`s* treatment, i.e., the statistical distribution of velocities among the particles of gas [52].

4.4. Heat and energy

In the year 1647, *Descartes* [127] became the first to propose the conservation law of the quantity of motion, presently called *linear momentum*, and showed it to be proportional to *mv*. Subsequently this idea was extrapolated by *Leibnitz,* who introduced the terms *'vis viva'* for the quantity mv^2 and '*vis mortua'* further related to *Newton's* gravitational forces. *Leibnitz's* idea of a 'vital force' was extended to an isolated system by *Lagrange* [136], when he assumed invariance of the sum of this quantity with the function of the coordinates of a particle, i.e., with their potential energy. The terms '*energy*' (ability for virtual work) and '*virtual displacement'* were used for the first time by *Bernoulli,* were weaving their path to a wider appliance very slowly and yet at the turn of 20th Century the term '*vis viva'* occurred still quite commonly. *Waterston* reported in 1845 [52] that the "*quality of perfect elasticity is common to most particles so that the original amount of 'vis viva', or acting force of the whole multitude, must for ever remain the same. If undisturbed by external action it cannot, of itself, diminish or increase.... striking against and rebounding from each other they undertake any possible mode of occurrence such that the particles are move in every possible direction and encounter each other in every possible manner during so small an elapsed interval of time that it may be viewed as infinitesimal in respect to any sensible period".* It was *Coriolis* who started to use the name 'lives force' for a half of its original value, mv^2*,* and thus simplified the relation with work. However, it was *Joule* who entitled the principle of work as mechanical power. In 1853 *Rankine* introduced the term 'potential energy' and thanks to *Tomson* the outlasting '*vis viva'* was finally renamed as 'kinetic energy'.

Not knowing what fire factually was, *Black* avoided speaking of it, but he studied the specific relations between the two measurable quantities of heat and temperature, which were not new in themselves. *Amontons* first used the effect of heat when he made an air thermometer. In fact, the use of this new instrument brought about the very question of how to define the quantity of heat separately of temperature, since its measurement is a function of both quantities. *Black* was interested in the way in which heat was fixed in bodies and he called this heat as "*latent heat*" – the heat absorbed or released by a body during a change of state without a change in temperature. Contrary to the standard understanding of heat absorption as the penetration of a fluid (caloric) through a porous body, the way of absorption of latent heat is not comparable and must be understood as a

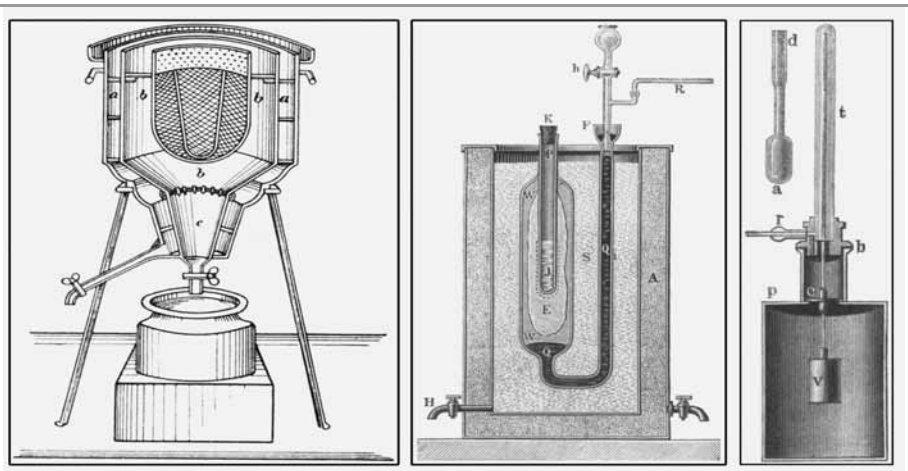

Fig. 22. – Time-honored ice calorimeter, which was first intuitively used by *Black* and in the year 1780 improved by *Lavoisier* and *Laplace*. The heated body is cooled down while placed in ice and the heat subtracted is proportional to the amount of melted water. In the year 1852, *Bunsen* proposed its more precise variant while determining volume instead of weight changes (middle). The cooling calorimeter was devised 1796 by *Mayer, Dulong* and *Petit*, but became known through the experiments by *Regnault*. Thermochamical measurements were furnished by *Favre* and *Silbermann* in 1852 using the idea of Bunsen ice calorimeter but replacing ice by mercury the volume measurement of which was more sensitive.

different, rather combined process that entails both the ideas of melting or boiling. *Black's* elegant explanation of latent heat to the young *Watts* became the source of the invention of the businesslike steam engine as well as the inspiration for the first research in theoretical thermochemistry, which searched for general laws that linked heat, with changes of state. Heat and its measurement were, however, to belong to mechanic-physics, were they were integrated into the economy of chemical transformations.

With little doubts, until the work of *Black* and *Irvine,* the notions of *heat* and *temperature* (from *temper* or *temperament* first used by *Avicena* in the 11th Century) had not been distinguished between. *Black's* work, together with that done by *Magellan*, revealed the quantity that caused a change in temperature but which was itself not temperature – the modern concepts of *latent heat* and *heat capacity*. They explained how heat is absorbed without changing temperature and what amount heat is needed to increase a body's temperature by one unit. Worth noting is the original proposal of a name for one unit of heat to be a *therm* (sufficient heat to warm 1g of water by 1^{o} C) or the proposal by *Groffith* to name it after the lesser known physicist *Rowland.* The description of latent heat and heat capacity answered, to some extent, the warning given by *Boerhaave* [54] in the beginning of 18th Century ..."*if we make a mistake in the interpretation of what is fire, this deficiency can afflict all disciplines of physics and chemistry, because in all natural creations fire is involved, in gold as well as in emptiness..".*

Rumford presented qualitative arguments for a fluid theory of heat with which he succeeded to evaluate the mechanical equivalent of heat. This theory, however, was not accepted until later approved by *Mayer* and, in particular, by *Joule*, who also applied *Rumford's* theory to the transformation of electrical work. The use of customary units called 'calories' was introduced by *Favren* and *Silbermann* in 1853. The characterization of one kilocalorie as 427 kilogram-meters was first launched by *Mayer* [136] in the year 1845. Regarding some impediments associated with the wider application of (only now traditional) units, such as calories and recently joules [J], the establishment of some practical links with traditional work [W=J/s] became necessarily accentuated. Therefore, an innovative unit '*horsepower'* (HP) was necessary to bring in as the performance measure thanks to *Watt,* who was unable to sell his steam engine to mines without telling the engineers how many horses each engines would replace, because the owners traditionally used horses to drive pumps that removed water. Jointly with another norm work power by then, produced by a healthy brewery horse (introduced and premeditated by *Joule* working as a Brewster), a horsepower unit was defined as 550 ft-lbs (~ 75kgm) of work every second over an average working day. It is clear that from that time the strong miner and brewery horse got off the use due to modern carriers and current 'average' horsepower would have to turn into somehow 'weaker' status of present 'racing horses'. Nevertheless it is steadily kept in traditional rating engines of cars and trucks. The other horse 'dimension' was otherwise important in mankind's history as was the separation of two horse backs, which became a factor for establishing the distance of wheels in Greek wagons, and later, it correlated with the separation of railways and profile of tunnels. Consequently it even gave the size of the external rockets in the US space program as their size was limited by the separation of railways and associated size of tunnels through which the rockets were transported to the launching sites

Nonetheless it took two centuries to replace the fluid theory of heat (*caloricum* or sometimes *thermogen)* by the vibration view (of the state of inherent particles) that was substantiated by the advanced theory of combustion by *Lavoisier. Sadi Carnot* provided the theory of the four cycle device [137]. However, the idealized theory of a heat engine was proposed on the confused basis of heat transport taking place in the form of a fluid (caloricum) discharging from the state of higher to lower tension ('conservation of materialistic caloricum') and in that time was also supported by *Clapeyron*. Notably *Carnot* excluded the existence of perpetual thermal motion, formulating an important efficiency theorem on the "*moving force of fire"*. Such a force does not depend on the medium used for its outgrowth but just on the temperatures of bodies between which the transfer of heat is conveyed.

Following the 1826 textbook by *Pencelet* [138,139], *Rankine* introduced in the year 1853 the term *energy* – actuality (*'ergon'* – actus and *'energeia'* – activity in the opposite sense to the possibility '*dynamis'* – potentia).

Simultaneously to the development of the separated field of electricity and magnetism, another important field of thermal sciences was introduced and named *thermodynamics (‘thermos’* – heat and *‘dynamis’* – force), first made known by *William Thompson* and preceded by *Maxwell’s* concept of thermal equilibrium [50]. Yet towards the end of Nineteenth Century [129,130], *Helmholtz* and *Laplace* described both theories of heat to be equally suitable to comply with a theory of temperature measurements because it was only determined by the state of the system under investigation. A similar understanding was anticipated for the internal motion of particles because heat was also a measure of the transfer of motion from one system to another – kinetic and potential energies being qualitatively different forms of motion (scaling variance in the degree of self-organization). Nowadays the transfer of heat is sometimes associated with a modern description in terms of non-integral dimensions of fractals.

The creation of the notion of entropy in thermal physics was a response to a similar problem in thermochemistry: the principle of the conservation of energy, always verified by physical-chemical transformations, could not be used to simply determine which transformations were possible and which were not. The state of equilibrium was defined by the fact that any spontaneous transformation that would affect it by diminishing entropy was impossible. Whilst a real steam engine functioned by real heating and cooling, the function of the ideal steam engine necessitated the fiction that two bodies of different temperatures would never be put into direct thermal contact. Thus the system is supposed never to leave the state of equilibrium whilst undergoing a displacement from one state of equilibrium to another, which is, moreover, infinitely close to each other and which is determined by an infinitely progressive variation of the controlled parameters. The problem of such a change description bears the same character as the time change during chemical reactions. *Duhem* called such changes ‘fictitious transformations’, which are reversible and entirely directed from the exterior when passing from one state of chemical equilibrium to another. *Van’t Hoff* and *Le Chatelier* associated this idea with the law of displacement of equilibrium and chemical thermodynamics received its central principle that dealt no longer with mere `energetic` but introduced thermodynamic potential as a minimum at chemical equilibrium. Physical chemistry, as an autonomous science in relation to mechanical physics, which has neither reactional events nor the second (entropy) principle, has brought thermochemistry to a level much richer than physics alone, see early calorimeters, Fig. 22.

Far from equilibrium [140,141], physical chemistry puts the accent on the global behavior of a population with local interactions. Such an idea may be also applied to the behavior of various societies, but the exact field of thermochemistry is more honored for two reasons. Firstly, it may encircle a great variety of cases capable of nonlinear coupling, and secondly, any creation

of molecular structures can even take place independently of the processes itself (like hydrodynamic whirlwinds). Characteristic of such systems is the nonlinear coupling between inherent processes (that produce entropy), which often shows the capability of self-organization [9,13,57,141]. The spontaneous production of spatial differentiations and temporal rhythms, are often called dissipative structures. Structure is here understood in a more general context and is most likely to exhibit coherent spatial-temporal activity, and is dissipative in nature because it occurs only under the condition when the dissipative process is forcefully maintained.

Links between the production of entropy and the production of coherence leads to the association of two sciences: thermo-dynamics and thermo-chemistry. Coherence, however, touches not individual molecules (that can be in the framework of quantum principles) but effects the population of whole molecular aggregates. Coupling of the rates of simultaneous chemical reactions, may even bring the possibility to arrive at a world characterized by the quantum-mechanic-constants [142-144] (*Planck quantum length, thermal length*). Here belongs *Buffon's* original idea of 'animated molecules' (now called *Brownian motion),* which was, after all, refused by *Brown* saying '*the motion of particles in a fluid cannot be due, as others had suggested, to that intestine motion which may be supposed to accompany its evaporation*` and such a cooperative motion can be seen (according to *Perrin* and *Nernst* [144]) as equivalent to the action of fluctuations as a natural consequence of randomness of molecular motion.

In the other words, chemistry can produce stable structures that store a kind of memory of their formation conditions. Standard crystallographic structures can function as a kind of relay between histories of different types of their formation and the make up of individual materials. The history can be re-constructed on the basis of a physically measurable property characteristic of these structures. The singular link between chemistry and plurality of interwoven times for a structure's build up was, therefore, the center of alchemical preoccupations.

When the validity of the conservation law of mechanical energy was generally recognized, the French Academy of Sciences did not accept any new proposal for the construction of mechanical '*perpetum mobile'*. At the same time, the widespread caloric hypothesis achieved important supporting results: the derivation of sound velocity with the use of Poisson constant (*Laplace)*, mathematical description of heat conduction (*Fourier* 1822) and the proof of the same maximum efficiency for all thermal machines (exhibiting the impossibility to construct any perpetual mobile of the second generation). Its author, *Carnot* also derived the direct proportionality, *f(T),* between the works performed in the 'fall' of the heat unit during an infinitesimal cyclic change of given working substance and within the corresponding temperature difference between the hooter and cooler reservoirs. It was written as the relation, $f(T) = C/(C_1T+C_2)$, where C's were constants and T is the Celsius temperature. The expression for

f(T) (corresponding to the related Clapeyron's term, *1/C*) was later named as Carnot's function, μ, equal to $(1 - \delta/\rho)\ dp/dT\ x1/\Delta H$, where δ, ρ and ΔH are densities of vapor and liquid, and the heat evaporation respectively. In fact, it was the first quantitative description of the equilibrium coexistence between the gaseous and liquid phases, currently known as the Clapeyron equation.

In 1850, *Clausius* published his first treatise on the new discipline on thermal science (not using yet the term 'thermodynamics', which was already introduced by *Thompson* in 1849) in which he reformulated and specified more exactly the two laws of thermodynamics and better specified the Carnot-Clapeyron relationship. In his famous publication "*On the modified form of the 2nd law of mechanical heat theory", Clapeyron* incorporated the possibility of compensation of the enforced negative processes by spontaneous positive processes. To the first class, the impossibility of transfer of heat from lower to higher temperatures was classified spontaneously (and similarly to the conversion of heat into work). The second class was aimed at the transfer of heat from higher to lower temperatures and the generation of heat by work. By mere intuitive and logical reasoning (which might remind us of a current field known today as synergetic) *Clausius* was able to prove that the implementation of processes can be quantified by an algebraic summation of the proportions of the heat content accumulated in the course of investigated process to the corresponding value of the absolute temperature.

For such a classical field of thermodynamics (understood in the sense of being a not too popular, but adequate term for 'thermostatics') the closed system defines and describes the energy conserving approach to equilibrium, which is, factually, thermal death (certainly, if neglecting ever-presented fluctuations). It bears similarity with the mechano-dynamics of an isolated system, i.e., fixed state of planets (or molecules) kept together by stationary orbiting. The next step is the true thermodynamics with thermal bath, capable to draw or reject energy as to balance the coexistence between the two phases divided by a phase transition. The counterpart in mechanical-dynamics is the existence of an external field acting, for example, on a stone dropped from a tower. The external fields are the source or sink of energy – momentum without being modified. Any disequilibrium must be created by, e.g., artificially created experiments (by `experimentationists`). However, for the case of increasing number of thermal baths we have no such an equivalent in mechanic-dynamics but we can account for the possibility of thermal cycles and we can get closer to the description of a situation met in the nature. This is the curiosity of thermodynamics, which, thus, diverges from that familiar in scholar mechanic-dynamics.

True reversible processes, however, served as an abstraction as they do not factually exist for macroscopic bodies under our control. By making interfering frictional effects small we may diminish the inherent entropy change almost infinitesimally – as much as we please. To do this we usually require slower and slower process, i.e., longer and longer time for its completion.

Therefore the reversible process has interest only as a standard of comparison not as a practical or desirable end in itself. We may cite *Sadi Carnot* "*we should not expect ever to utilize in practice all the motive power of combustibles. The economy of the combustible is only one of the conditions to be fulfilled in heat engines and within many other aspects it may become only secondary*".

4.5. Atomists and matter

In 1675, *Lemery* published [145] "The Course of Chemistry", which had an enormous impact on its progress because it finally released from most references to occult qualities. For *Boyle* in his time-honored "Sceptical Chemist" (1661), the consequence of mechanist atomism was that all chemical bodies, whether we could resolve them or not, were produced by 'different textures' of a 'catholic or universal' matter, i.e. an arrangement of particles 'without qualities' would be responsible for what we call properties (characteristic qualities). Boyle's definition that holds as *'I now mean by elements certain primitive and simplest bodies, or perfectly unmingled bodies, which not being made of any other bodies, or of one another, are the ingredients of which all those called perfectly mixt bodies are immediately compounded, and into which they are ultimately resolved'* and was later known as a 'negative empirical concept' enabling modern definition of the element.

According to *Newton*, atoms were solid, heavy, hard, impenetrable and mobile particles that God made at the Beginning, but he did not accept the idea that atoms were characterized only by the force of inertia – a passive principle in virtue of which bodies remain in movement or at rest meaning that there would be neither destruction nor generation (as with life). Such a corpuscular chemistry as a site of conceptual experimentation on the sequence of atomism, assumed that the constituent elements did not continue to exist 'potentially' in a compound but composed it actually. Chemical transformation had to be thought of in terms of the separation and combination of particles, which were thus assumed invariant and incorruptible, existing prior to combinations and remaining themselves in '*mixts'*.

From the atomist point of view, *Aristotle's* concept of passage from potentiality to actuality no longer made sense. Correspondingly, genesis (*genesis)*, destruction (*phthora)*, and alternation (*alloiosis)* no longer referred to qualitatively different processes but to a kind of quantitative change, that *Aristotle* called locomotion (*phora)*. Atomism, was seen as a '*methaphor*' for the alphabet, and the 'tiny bricks', which can provide a solid construction, were thought to be atoms, which became a principle of both reality and knowledge. There, however, remained a question: what caused the homogeneity? The concept of mixture reemerged, recalling what *Aristotle* stated as *`stoicheia`*, which are the constituent elements of a body and which can be transformed during the process of decomposition. *Aristotle* also asserted that the '*dynamis'* of the elements remained in the '*mixt',* in other words, the properties of a mixt

reflected the properties of its constituent elements. From the point of view of chemical operations, corpuscular chemistry tended to favor those procedures that were reversible. With the distinction between primary properties (extension, form, mass) and the secondary ones (heat, sound, color) the mechanist version of atomism denied all qualitative differences to atoms and only granted such differences to geometrical attributes.

As a consequence of the opposition between 'simple' and 'compound', there is the famous *Lavoisier's* definition of an element "*if we give to the name of elements or principles of bodies the idea of the last step that analysis can reach, all substances that we have not been able to decompose by any way whatsoever are elements for us, they act to as simple bodies and we must not suppose them to be decomposed until the time when experiment and observation will have furnished the proof"*.

We certainly should not forget *Lomonosov* who was the first physical chemist to view chemistry from the standpoint of physics and mathematics. He considered matter to consist of minute imperceptible particles "*the oscillation and rotation of these particles increases on heating and when rotary motion reaches a certain stage the material melts or volatilizes. The particles in gases move more rapidly than in liquids and collide with each other*". His ideas were ahead of those of *Lavoisier* on the nature of heat and on its resultant effect on materials.

The Swedish chemist *Berzelius* [146] explained in the 1810s the action of the newly invented electrical battery and associated process of electro-deposition. He defined each simple substance and each compound body by a positive or negative polarity whose intensity varied according to the nature and the number of the positive and negative charges carried by the atoms of each element. The voltaic battery was not seen as a simple instrument but as a 'principle of intelligibility' where electricity was understood as the primary cause of all chemical action. The "electrical fulfillment" was actually the original Newtonian dream of mechanical actions between atoms. On the basis of opposite forces it was possible to design a simple method for predicting the degree of affinity: the scale of mutually reacting elements from the most electropositive to the most electronegative.

Dalton [135] made use of *Proust's* law as the basis for a new atomic hypothesis and suggested that chemical combinations take place in discrete units, atom by atom, and that the atoms of each element are identical. These atoms differed from *Newton's* corpuscles because they presupposed neither the void nor attraction and made no attempt to explain properties of simple bodies in terms of a complex architecture whose ultimate constituents would be atoms. After the guide of *Dalton's* new system of chemical philosophy, *Gay-Lussac* announced that the volumes of gases, which combine with each other, were in direct proportion – the volumetric proportions thus confirmed by the gravimetric ratios. The first law, to fashion a network of experimental facts from different

disciplines, was formulated in 1811 by *Avogadro,* stating that equal volumes of different gases contain the same number of molecules.

Dulong, with his young colleague *Petit,* undertook their study of the quantity of heat needed to raise the temperature of one gram of a substance by one degree Celsius. In this manner, they determined heat capacities of each atom to be nearly the same (convenient notion is gram-atom which was earlier specified as 6 cal/$^{o}C^{-1}$ gram-atom^{-1} , today's expedient as about 25 J mol^{-1} K^{-1}). They concluded, "*the atoms of all simple bodies have the same heat capacities*". It is now called the *Dulong* and *Petit's* law of specific heat and was based on a new field – the above-mentioned calorimetry. This law could not lead directly to the atomic-weight values but it presupposed them. It was followed by the theory of chemical proportions derived upon isomorphism where only the number of atoms determined the crystalline form, and little angular variations attributed to the nature of individual atoms.

In a jungle of obscure and exotic terminology, it was often difficult to read chemical texts. In the year 1860, during the probably the first international Chemical congress, held in Karlsruhe, participants tried to put an end to these deep differences on words and symbols that harmed communication and discussion. It raised a fundamental theoretical issue for the agreement on figures and formulas to be subordinated as well as the definitions of basic concepts: atoms, molecules and equivalents. Moreover it materialized the existence of an international chemical community and defined the rules for its functioning

In 1865, the English chemist *Odling* published the table of elements, which was almost identical as that published five years later by *Mendeleev* [147], although they did not entirely believe in the existence of atoms as particular species. The individuality of the chemical elements was, for *Mendeleev,* an objective characteristic of nature, which was as fundamental as the Newtonian gravitation; it was both a condition and a product of his periodical classification having a real, and not just a theoretical meaning. His periodic classification was far from being prophetic of the electronic structure that is today so well known and, ironically, those defenders, who were in favor of the existence of the previously popular unique 'primordial' element, criticized it. *Mendeleev* protested against this misuse of his discovery and when he learned about radioactivity and about the electron, he even advanced his explanation in terms of vortices of the ether, which take place around the heaviest atoms. Thus *Mendeleev* initiated an unfortunate hypothesis about the ether as a definite element and placed ether above the column of rare gases. Periodic classifications, see Fig. 23**,** drew a lesson

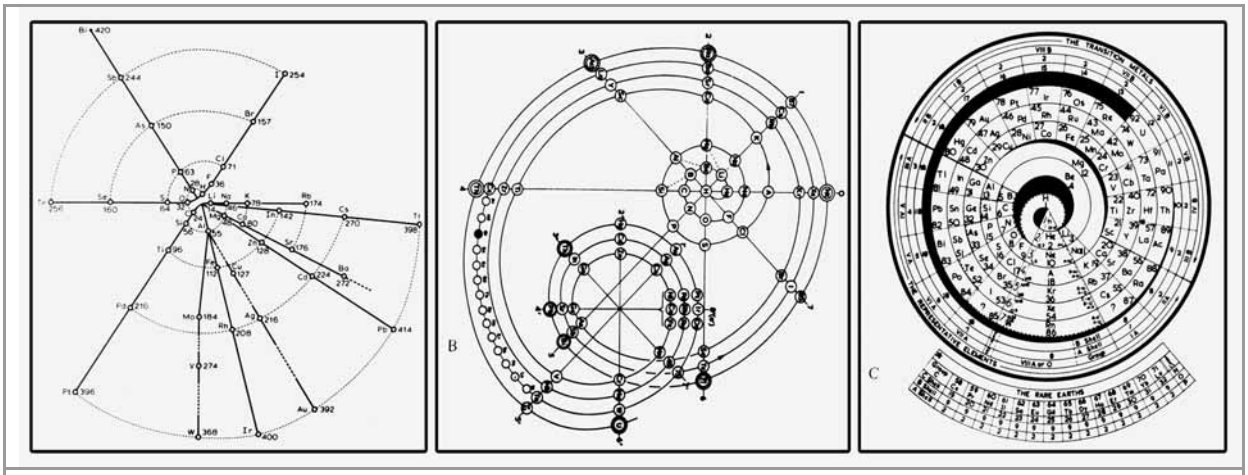

Fig. 23. – Various systematization of the elements periodicity [9] preceding and following the accepted periodic system introduced by *Mendeleejev* 1870. Left, simplified system pioneered by *Hinrich* in the year 1867, the twisting modification challenged by the German chemists *Nodder* (1920) up the recent spiral alteration (right) anticipated by the US chemist *Emerson* (1944). It is worth noting that these modifications show some signs of the ancient attempts of counting numerical symbolism as well as a natural tendency to take shape of spirals (cf. Fig. 64). Courtesy of *Vladimir Karpenko*, Praha, Czechia.

from the chemistry of substitutions and, correlatively, substitution lost its subversive status – it remained no more than one mode of combination among others.

In 1750, the German physician *Eller* published the first tables presenting solubility data of various salts and their mixtures in water at different temperatures (and indication of atmospheric pressure). The first database, however, was most likely done by the Swedish chemist *Bergman* (1783) who put in to order several thousand chemical reactions (containing 49 columns with 27 acids, 8 bases, 14 metals and others, and discriminated between reactions by a wet method in solution and a dry method by fire). Besides foregoing recent databases he also helped to circumscribe nomenclature. Reactions were no longer ‘means’ but became ‘phenomena’, which countered anomalies and had to extend between the chemical affinity and the other physical factors that emerge obstacles in its completion. Only the clairvoyance of the Russian chemist *Beilstein* laid the true grounds for modern databases when he originally published a survey of 15 000 organic compounds as a series of books published in the period 1880–1883, the continuation of which exists as a well respected database until today.

The important process of synthesis was not first distinguished according to the nature of the product (natural or artificial). Synthesis was thought to be merely total or partial. Substances were made from elements (commonly C, H, O) or from other, simpler compounds. *Wohler’s* laboratory synthesis of urea in 1828, a substance made previously only by the action of a living organism, was celebrated as an event of unprecedented importance, demonstrating the

nonexistence of the ‘vital force’ that had previously been necessary to create organic molecules. In 1847 *Frankland* discovered a new class of organometallic compounds, a concrete argument in favor of a reunion of organic and inorganic chemistry, which also became a starting point for the modern theory of valence (introduced instead as ‘atomicity’). In fact it was a fruitful time for new scientific images such as that of *Kekule* who said that he owed his career to the vision of the ring structure of benzene as a snake chewing on its own tail (cf. Fig. 12.).

After the invention of bakelite, prepared from phenol and formalin in 1907, *Baekeland* introduced the generalized term ‘plastics’ in 1909 to design a larger class of products conceived as replacement products for natural substances, which were either rare or costly. They were a triumph of substitution chemistry and in the 1950s seemed to take on aesthetics of their own. Polymers were technological items before they were objects of knowledge. Laboratory chemists were annoyed when syrups did not crystallize or with solids that were impossible to melt and they mentioned them in notes as substances of unknown structure. Thermo-hardening properties were used to fashion a variety of objects, their structure yet unknown. Although there was a hypothesis that molecules joined together in chains by ordinary interatomic bonds (advanced for isoprene in 1879), most chemists from the beginning of the nineteenth Century thought that a pure body must be composed of identical molecules of small size. Macromolecules were explained as an aggregation of small molecules, which was later verified by crystallographic research.

Without being self-confident that crystals are internally arranged in a periodical manner *Bravais* mathematically described, in the year 1850, fourteen geometrical figures that can be periodically arranged in the space and characterized them as a combination of one or more rotations and inversions in a lattice, which is understood as a regular array of points (each point must have the same number of neighbors as every other point and the neighbors must always be found at the same distances and directions. All points are in the same environment. His idea was later approved by X-ray diffraction (*Röntgen* 1912) and this approach has been advantageously applied until now so that the so called ‘Bravais Lattice’ is understood as a three dimensional network, which tiles space without any gaps or holes (there are 14 ways in which this can be accomplished). Microscopic investigations made by *Reinitzer* when studying cholesterol in 1988 extended the developing basis of crystallography to the sphere of liquid crystals (later widespread to generality by *Lehmann*).

In 1855, the young pathologist *Fick,* wrote a work entitled “*Uber Diffusion*” published in Zurich “*Annalen der Physik*”. Surprisingly, *Fick* was an experimental physiologist, but his work on diffusion became theoretical and his approach would today be called a phenomenological liner-response theory applied to mass transport. He started observing “*diffusion in water confined by membranes is not only one of the basic factors of organic life, but is also an*

extremely interesting physical process and, as such, should attract much more attention than it has so far". As a matter of fact the carrier particles involved in their current have to flow against a concentration gradient, which is analogous to Ohm's Law of electric current and Fourier's Law of heat flow. Assumingly, Fick`s phenomenology missed the probalistic point of view that is central to statistical mechanisms and it was Einstein who 50 years later derived the diffusion equation from the postulates of molecular theory, in which particles move independently under the influence of thermal agitation.

The two most traditional actors in chemistry, the chemical reaction and heat, were joined to conceive 'thermochemistry'. Just as the fall of a body is characterized by the work of mechanical forces, the decrease in potential energy and the creation of kinetic energy, a chemical reaction must be defined by the work of chemical forces and the decrease in potential of these forces. Work and decreases in potential were measured by the amount of heat released by reaction. The state of equilibrium thus became the state in which the potential of chemical forces had reached its minimum value. It was a transposition of the old doctrine of effective affinities and corresponds to the discrimination among chemical reactions. The natural chemical reaction was the one spontaneously giving off heat while the endothermic reactions were considered constrained by an external action, by the chemist who adds the heat (preference to higher temperatures).

In 1867 *Guldberg* and *Waage* proposed a law that abolished any distinction between exothermic and endothermic reactions and created a new analogy with physics. They put forward the idea of 'active mass' in analogy with Newtonian force, i.e., the chemical force of a reaction was defined as the product of the active masses, and equilibrium was reached when the forces of opposite reaction became equal. However, the relation between forces and masses involved a specific coefficient of activity. It was a great success but it left open the question of its interpretation. In this hypothesis equilibrium was no longer defined as a state in which a reaction stopped but the state in which reaction rates were such that there effects compensates for each other. Equilibrium was not the state where forces, and the rates they determined, both vanished and therefore it was nothing special – just as the analogy with reactive collisions between molecules, which determined the given reaction, were on the whole as numerous as the collisions that determined the inverse reaction. The central concept of the current field called 'kinetics' is thus the probabilistic notion of frequency dependent on temperature.

Finally we come to deal with structures, ideal and real, associated with variety of defects, impurities, vacancies, interscialities, interfaces, etc. – these terms imply the usual hierarchy, the ideal being the prototype from which we can know about real things and their inevitable deviations. But henceforth it is the *defect* that is interesting, for the specific properties it gives the single crystal – in the larger scale it is its matter-separating surface specifying its outer form and interfacial properties. The individual crystalline body is no longer a mere

imperfect version of the ideal prototype but the reflection of the singular history of its formation, growth and orderliness. The possible multiciplicity as well as both the scientific and industrial interests for particular properties linked to the digression (accidental deviations) from the established laws (predictable state) were disposed to remain between the boundary status of 'defects' (a non-hierarchical group of cases, each associated with the circumstances that favor it) and 'normal cases' (as demonstration of rules).

By penetrating the micro-, supra- or nano-molecular world [88,89] and playing with the interactions among molecules in the standard three- but also in two- and even in the one-dimensional range (quantum wells or dots), the physical chemists has become a new kind of architect of matter, facetiously saying 'tricky designers for tricky matter'. Among others we may mention optoelectronics, superconductors, magnetics or, particularly, alloys with shape memory, self-adjusting photochromic glasses, bioactive ceramics and cements or quantum-well semiconductor microelectronics. Such kind of sophisticated materials are often called *intelligent materials* [87], in the sense, as if the chemists had breathed life into matter and accomplished and old dream of alchemists.

We are aware of the great environmental cycles [70,77,84] of nitrogen, oxygen, carbon, phosphorus or sulfur and identified the succession of transformations, each one consuming what was produced previously and producing what would be consumed afterward. It is a beneficial self-recyclation (cf. Fig. 7), like a desired industrial assembly line in perpetual motion, which is looping back on its beginning [83]. But what is the a thermo-chemical balance if it does not integrate the many time horizons of those different processes that together create the overall global transformation [9,77,81,82] – we still have to learn a great deal!

4.6. Underpinning of thermodynamics

Towards the end of the 17^{th} century *Papin* succeeded in proving that water can exist in a liquid state even at temperatures exceeding its boiling point if heated under increased pressure. It preceded the discovery of the *critical state* of substances and the determination of their critical values of pressure, volume and temperature (often named as 'disliguefying' or 'absolute boiling' points after *Andrews, Faraday or Mendelejev*). Experimental evidence [135,146,147,148] initiated shaping of appropriate state equations of a real gas intending to replace somehow unsatisfactory technical analysis using the state equations for an ideal gas (already introduced by *Regnault* in the year 1847). The '*virial*' of external forces (~3pV), suggested by *Clausius* twenty years later, descibed the difference between the behavior of real and ideal gases. It was centered on the mean free path of a molecule and the potential of intermolecular forces was taken as being proportional to $1/V^2$, thus replacing thus the complicated function of *Laplace* that was based on the model of stationary

molecules repelling each other due to their caloric envelopes (though satisfactorily explaining the surface tension, capillarity and even cohesion). The use of reduced values by *van der Waals* (1880) enabled him to postulate the *law of corresponding states* based on the state parameters expressed in the units represented by their critical values.

The most important personality in thermodynamic history was credibly *Gibbs* who discriminated that a system of r coexistent phases, each of which having the same independently variable components, n, is capable of $(n + 2 – r)$ variations of phase, known until now as the famous 'phase rule', that factually unveiled that the whole is simpler than its parts. It followed that for temperature, pressure and chemical equivalents ('potentials' later specified as 'chemical potentials' by *Ostwald*) the actual components bear the same values in the different phases and the variation of these quantities are subject to as many conditions as there are different phases (introduction of partial derivatives). This important work on the theory of phase equilibria was published in the period 1873 to 1878 in an almost unknown journal "Transaction of Connecticut Academy" and its insufficient publicity was fortunately compensated by the proper recognition of renowned scientists [135,146-151], such as *Maxwell, Duhem, Ostwald* or *Le Chatelier,* also mentioning the Dutch school of thermodynamics, that must be particularly credited with the broader application attempts aimed at the problems of general chemistry and technology.

One of crucial focuses was the clear-cut meaning of entropy often specified to considering the case of mixing two gases by diffusion when the energy of whole remains constant and the entropy receives a certain increase. We may cite *Gibbs* quoting [151] "…*in the mixture of two identical and ideal gases by diffusion an increase of entropy would take place, although the process of mixture dynamically considered, might be absolutely identical in its minutes details (even with respect to the precise path of each atom) with process which might take place without any increase of entropy. In such respects, entropy stands strongly contrasted with energy. Again, when such gases have been mixed, there is no more impossibility of the separation of the two kinds of molecules in virtue of their ordinary motions in the gaseous mass without any special external influence, than there is of the separation of a homogeneous gas into the same two parts into which it has once been divided, after these have once been mixed. In other words, the impossibility of an uncompensated decrease of entropy seems to be reduced to improbability*…".

Another important area of Gibbs's interests was the depiction of a fundamental dependence of the intrinsic energy of a one-component system versus volume and entropy, often called the '*thermodynamic surface'*. It helped in the distinguishing of individual areas of stability in single- and multi-component

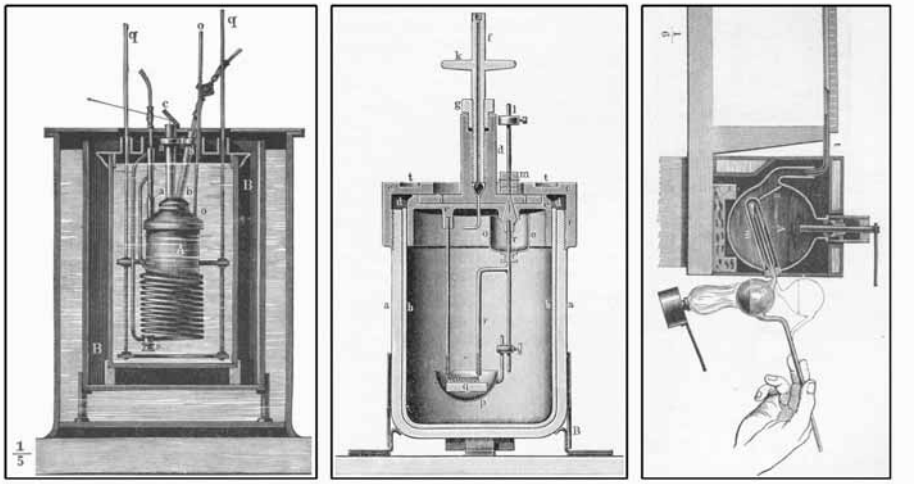

Fig. 24. – *Favre* and *Silbermann* are not widely known for their early construction of a combustion calorimeter, which was adjusted for higher pressures by *Berthelot* (known as today's calorimetric bomb).

systems that are in an equilibrium coexistence and which yield a whole what is now called "*surface of dissipated energy*". This method for investigating the equilibria of many-component systems, with the use of equality of the potentials of all the involved components in all the existing phases, became widely accepted after the introduction of the quantities of the *escaping tendency* (1900) or 'fugacity'(1901). Finally the term '*activity'* was lastly introduced by *Lewis* in 1907 as relative [150] and established in the current meaning in 1913. Curiously *Lewis* was involved in various thermodynamic applications reaching even to the realm of economics [152].

In the last quarter of the 19th century the theory of *metastable phase equilibria* marched under a more serious consideration although the formation of non-equilibrium states of pure substances and their mixtures had been experimentally proved long before (e.g. *Fahrenheit* published in 1724 experimental results on undercooled water). Gibbs was the first to use the term *unstable* equilibrium while the authorship of *metastable* is ascribed to *Ostwald* who in parallel with the term *labile* presented an exact definition of its meaning as early as in 1897. *Van der Waals* modified the original Gibbs's terminology of *limit of absolute stability* to 'binodal' (points of contact of the common tangential planes within the Gibbs's thermodynamic surface were named as 'nodes' according to mathematician *Cayley)* and the *limit of essential instability* were called 'spinodal' (i.e., curves dividing the concave-convex surface into areas convex in all directions and those remaining completely concave). It is also worth noting that these purely theoretical considerations led to the discovery of two rather extraordinary and less known phenomena, such as 'retrograde' condensation and the 'barotropic' effect.

At the turn of 20th century a more modern nomenclature also emerged, such as the notion of a *eutectic* mixture and a eutectic point introduced by

Guthrie (derived from the Greek expression used already by *Aristotle* in a similar sense of being easily melted – 'eutektor'), followed by 'peritectic' reaction (*Lehmann)* or 'eutectoid' (*Howe*). The progressive nature of both the theoretical and experimental treatments of this period is manifested in the fact, that the described phenomena were not yet fully understood yet. It was helped by the new approach called *thermal analysis* (*Tammann* 1905) that enabled the determination of composition of the matter without any mechanical separation of crystals just on basis of monitoring its thermal state by means of its cooling curves – the only method capable of the examination of hard-to-melt crystal conglomerates. It brought along a lot of misinterpretations, the legendary case of the high-alumina regions of the quartz-alumina binary system continuously investigated for almost hundred years. It, step by step, revealed that the mullite phase irregularly exhibited both the incongruent and congruent melting points in dependence to the sample course of equilibration. It showed that mere thermal analysis is not fully suitable for the study of phase equilibria, which settle too slowly. In 1909 there was elaborated another reliable procedure of preserving the high-temperature state of samples down to laboratory temperature, factually *freezing-in* the high-temperature equilibrium as a suitably 'quenched' state for further investigation. It helped in the consistent construction of phase diagrams when used in combination with other complementary analytical procedures, such as X-ray diffraction or metallographic observations.

Among the generalized applicability of the fundamental laws of thermodynamics is the description of the equilibrium coexistence of a mixture's phases became important. *Kirchhoff's* relation, which enabled the calculation of *'the amount of heat, which is liberated when a certain mass of water dissolves the minimum amount of salt as it is capable to dissolve*', represented the first of these (cf. Fig. 24.). Another case was Raoult's law for the decrease of the melting point of a solution as well as the decrease of pressure of the solvent's saturated vapors over the solution. In the year 1884 the relationship, earlier derived by *Gulberg* for the depression of freezing point and the solute-solvent ratio, was taken over by *Van't Hoff* in his extensive treatise when calculating, for the first time, the osmotic pressure of a solute. Here also belonged the first derivation of the 'liquidus' in the phase diagram of the condensed binary system for the region of the low contents of solute (say for the phase 2) familiarly known in the form of $dT/dx_2 = RT^2/\Delta H_{2\ (melt)}$ and later derived also by *Planck.* However, the author of a more general relationship was *Le Chatelier* in 1885 who proposed a logarithmic function of composition of a saturated solution in the form $dx/x = (k/\sigma)Q\ x\ dt/T^2$ where x, k/σ and Q are the ratios of amounts of substances of solute and solvent, the proportionality constant related to gas constant and the molar heat of dissolution, respectively. A few years later it was improved by *Shreder* in his description of a solvent by the equation, $\log x = -\Delta H_{(melt)}\ [T_{(melt)} - T]/(R\ T_{(melt)}T)$ since then known as the *LeChatelier-Shreder* equation. It was based on the assumption that the molar heat of dissolution over

the whole range of temperatures and compositions is constant and equals to the molar heat of fusion of the pure component, i.e., showing the relationship $\Delta H_{(sol)}/T \approx \Delta H_{(melt)}/ T_{(melt)}$.

Important studies were performed by *Lewis* who defined the 'perfect' (later termed as 'ideal') solution already in 1901, thus following van't Hoff's idea, which became extraordinary fruitful in the further development of thermodynamics of mixed systems since it enabled rational thermodynamics to sort out the solutions based on the differences between the behavior of real and ideal mixtures. Rault's law for extremely diluted solutions involved the use of an equality of differentials of logarithms of the absolute activity, *a*, and that of the mole fraction of a solvent, *x*, yielding $d \log a = d \log x$. *Guggenheim* classified solutions according to the experimentally determinable parameters, employing the dependence of the excess of Gibbs energy of mixing, $(\Delta G^{ex})_{mix}$ proposed as a combination of symmetrical and asymmetrical functions. *Lewi's* model of an ideal solution was applied to molten salts in 1945 by *Těmpkin* who took the limit of solution of this kind for a mixture of two independent ideal solutions of ions with a coinciding sign of charge.

Adjusted field of innovative statistical thermodynamics reached important authority thanks to *Boltzmann*, who kept persuading (and succeeded to convince his followers only after his 1906 suicide) the validity of logarithmic relation between phenomenological entropy and microscopic complexion, which equation was, factually, not his invention as it has already been applied to games of chance a century earlier by the French mathematician *DeMoivre.* Nevertheless *Boltzmann* found its new utility in thermodynamics and later *Shannon* yet another efficacy in communication, both applications dealing with a new specification called *uncertainty*. It has become an everlasting discussion what is the nature of uncertainty and its interconnectivity between individual topics. It was accepted that for thermodynamics uncertainty reflects something fundamental about the system as one cannot know in which microstate such a thermodynamic system happens to reside at any instance because it fluctuates stochastically among an ensemble of such microscopic possibilities. On the other hand, in information, the uncertainty was not seen thus fundamental as it rather reflects the fact that a given message or sequence is but one of many that might have been generated from a given symbol set so that once the sequence is specified the uncertainty seems to fade away.

Apparently, it was found apprehensive to know a thermodynamic system in general for which we routinely need some representation about certain in-depth make-up (microscale processes), which, however, may be dependent on the model applied. We may recall *Gibbs* citing "*…in spite of certain incomplementarities of thermodynamic and statistical approaches they are inseparablyconnected with each other, i.e., thermodynamic values are averaged on the whole system means of physical values, which are considered in detail by statistical physics. In this sense the statistical approach would justify the*

thermodynamics from the mechanical point of view. On the other hand, the same thermodynamic values, which are observed in physical reality, can be considered as some kind of guidance through the labyrinth of statistical theory, although such a kind of guiding can be rather blind…".

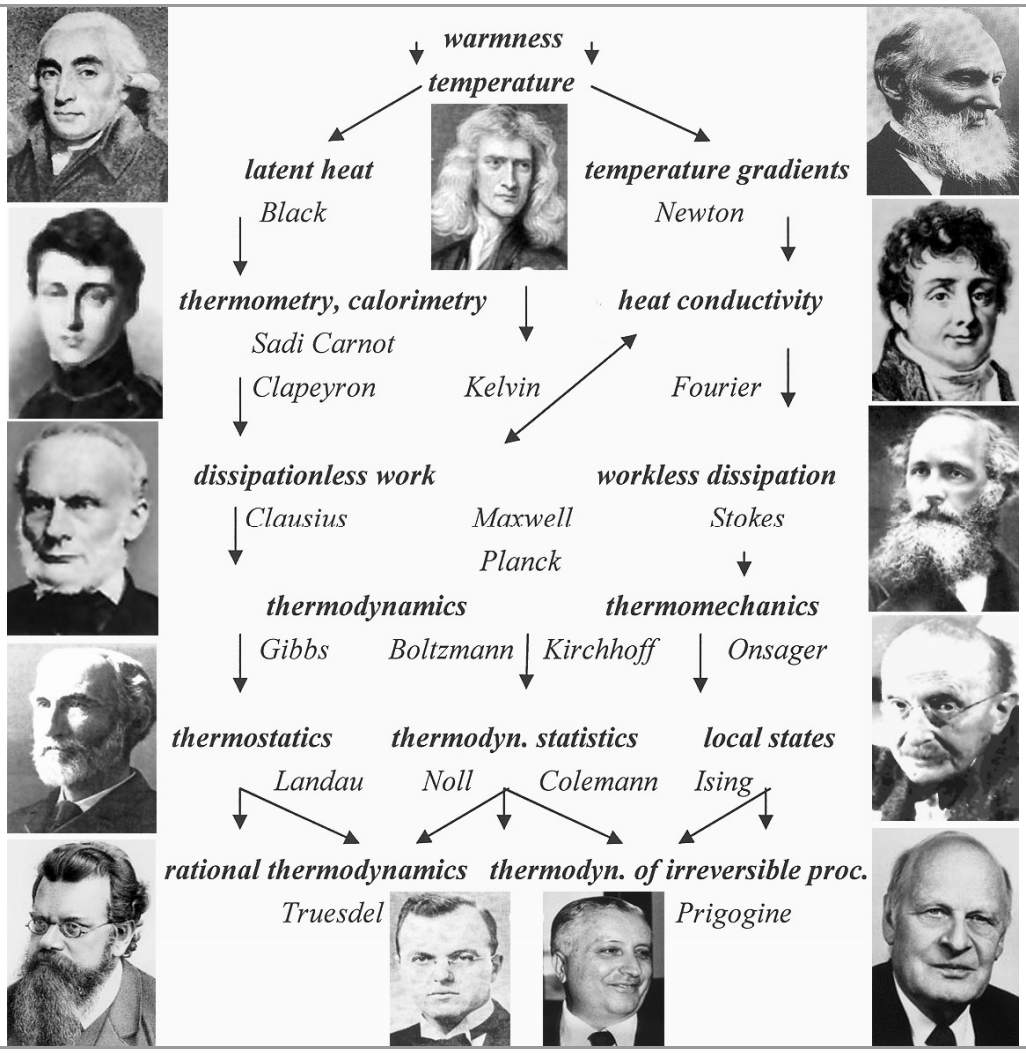

Fig. 25. – Approximate sketch of the growth of thermodynamic conception with the portraits of some famous pioneers, left column from above: *Joseph Black* (1728-1799), *Sadi Nicholas Carnot* (1796-1832), *Rudolf Julius Clausius* (1822-1888), *Josiah Willand Gibbs* (1839-1903), *Ludwig Eduard Boltzmann* (1844-1906), right: *Kelvin*, Baron of Larges, Lord Williams Thompson (1824-1907), *Jean Baptiste Fourier* (1768-1830), *James Clark Maxwell* (1831-1879), *Max Carl Planck* (1858-1947), *Lars Onsager* (1903-1976), middle: *Sir Issak Newton* (1642-1726), *Clifford Ambrose Truesdell* (1921-) and *Ilya Prigogine* (1917-2003).

In the middle of the 1920s, there arose an important period of the *Onsager* revolution initiated by his article on "Reciprocal Relations in Irreversible Processes" [153], which actually followed a kind of quantitative thermal analysis. It was based on the accomplishments made by *Ising* when describing the thermal behavior of a linear body consisting of elementary magnets under the assumption of interaction of their nearest neighbors. It was preceded by the definition of order-disorder transitions and the formulation of a general model of

the second order phase transition according to which the system reveals the so called λ-point of transition, which is easy to characterize by an order parameter with zero and non-zero values above or below this transition temperature. In this treatise *Landau* also proposed an expansion of the *Gibbs* energies into a power series and entered, thus, the world of broadened phase transitions. It was just the starting point of modern theories of irreversible processes (*Coleman, Prigogine, Truesdel,* cf. Fig. 25).

Quantum mechanics brought about a real revolution [154]. It may be said that 'Hamiltonian physics' was kept alive in the halls of Academies while the 'theme of entropy' subsisted in the workshops of the smiths where it was actually born. The predictive power of quantum mechanics was upheld in connection with the concept of periodic states of motion; it returns and repeats itself, in this way carrying recognition. In the modern inflowing concept of lively disequilibria, the concept of entropy became important, showing that dissipative systems are profoundly different from Hamiltonian systems, which can be formalized from the unifying principle of minimum action. Hamiltonian systems come, in general, from a well defined variation principle; it provides an important apparatus for conservation laws and symmetries and produces great simplifications as well as bringing one close to a solution. Initially distasted systems of yet mysterious dissipation do not have an equally general formulation, they are open, non-isolated, they interact with the outside and exhibit generalized properties being possibly the reason why they are sometimes considered scientifically 'less aristocratic' and, thus, worthy of increased attention. In contrast to the classical perception of equilibration, for a dissipative system the state of motion literarily dies out unless energy is constantly provided.

4.7. Thermal radiation and the modern concept of vacuum

In the year 1874, the Italian experimental physicists *Bartoli* [155] put a forward an idea of bringing electrodynamics and thermodynamics into the treatment of heat radiation, which is often thought to become a major source of inspiration for the later concept of *Stefan-Boltzmann* Law of blackbody radiation [156]. Light pressure, however, was not a new subject and played important role with respect to the competing theories of light: the corpuscular emission was taken to imply the existence of light pressure whereas the wave theory was usually regarded as incompatible with such a pressure. In 1870, *Crookes* constructed his radiometer ('light mill') and interpreted its motion by result of mechanical energy of radiant heat. In 1873, *Maxwell* noted in his new electromagnetic theory that "*in a medium in which waves are propagated there is a pressure in the direction normal to the waves … and that falling rays might perhaps produce an observable mechanical effect on delicately suspended things in vacuum…and he calculated that for the maximum sunlight to be about 8.82 10^{-8}lb per square foot".*

At the same time, *Maxwell* also enlightened *Kepler's* observation that the comet stream is tailed away from the sun upon the pressure of the rays falling from the sun. In 1924, the Russian scientist and rocket theoretician *Ciolkovskii* first realized that the pressure of sunrays could be used for propelling a cosmic vehicle furnished by suitable radiation-reflecting sail in the moment when it is lanced out to the cosmic space. As early as in the year 1970 the effects of sunrays were utilized to successfully orient the Mercurial probe 'Mariner'. The recent calculations provided by NASA revealed the estimate that a cosmic sail-ship could be accelerated to the speed five times faster than that achievable by conventional rocket drive. If such a sailor would be launched in the year 2010, it would meet early cosmic probe 'Voyager' in the year 2018, i.e., within eight years it would exceed the distance that 'Voyager' needed forty years to pass. Currently there are several successful (and also unsuccessful) missions, which employed such a sunrays drive for its acceleration, for example, the UNESCO spacecraft 'Star of Tolerance' with the projected sail area of 1600 m^2 or the proposed sailing vessel 'Cosmos' by the American Planetary Society. Such assignments, however, are still under the scientific disputation whether an absolute reflection of solar photons on the finished mirror would follow the laws of thermodynamics (requesting upon the gain of mechanical energy a change of temperature through the change of the photon wavelength).

However, the examination of light balances (rather than light mills) was actually due to the need to distinguish between the direct action of radiation and the indirect action caused by convection currents in the residual molecules in vacuum, resulting from heating. *Bartoli* adopted the *Clausius* version of the second law of thermodynamics restricting heat transfer from a colder to a warmer body without a compensating amount of mechanical work being performed. *Bartoli* imagined a perfectly evacuated system consisting of four concentric shells. The outermost and the center shells were firm black (fully absorbent) bodies while the intermediary two shells were contractible (and upon the need also removable) with a perfectly reflecting surfaces on both sides. The spaces between two outer and inner shells, were thermally isolated while the outermost and central shells, when the other two were in thermal equilibrium. Its function, however, required some artificial operations: at a given moment the destruction of the second outer shall produces radiation of heat in the entire space in between outmost shell reached thermal equilibrium, the second shell is re-created and the third shell is destroyed. Thereupon the second shell is contracted as far as its radius becomes equal to that of third. On repetition by cyclic operations, a definite quantity of heat is taken from the outer and transferred in to inner shell. Such transfer allows, however, an unconstrained assumption that the temperature of the third shell can be higher than that of outer one.

Assuming that the inner shell is a finite system with an intrinsic quantum property to expand, the process will be "spontaneous". We have to do with the

case where “the heat passes spontaneously from a colder body to the hotter one”, which is in a clear contradiction with the second law of thermodynamics in the original *Clausius'* wording. Such a straightforward argument is rather naïve (however, not too rare in the literature) and does not stand the confrontation even with a more advanced *Clausius'* formulation of the second law of thermodynamics claiming: “*a passage of heat from a colder to a hotter body cannot take place without compensation*”. The “compensation” here means a change within the system, which eventually has in consequence in the “natural” heat transport from a higher to a lower temperature. At first glance, it is very tempting to judge that the “compensation” is realized here by the expansion of the inner shell followed by the heat flow from the hotter soot to the colder calorimeter. However, the inner shell itself is considered to behave like a usual mechanical-thermodynamic system conservatively closed, which was provided at the moment of its creation (with some initial potential energy and then being a part of the system). Even in this case, one can conclude that there is nothing strange and that no violation of the second law takes place. It has had important consequences in various experimental and thought proposals to construct such a devises [157] and even has led to the possibility to violate the second law of thermodynamics, the discussion of which has been lasting until now and even growing deeper [158].

Such an original, qualitatively thought experiment seemed merely to have served as a heuristic guide for *Bartoli* to consider the existence of light pressure. Later he approved this highly artificial construction by a more realistic variant in which the spherical shells were replaced with a classical cylinder (with permeable and reflecting walls) operculated with crest and tail lids (fixed as blackbody) and operating with two moving pistons as heat reflectors [156]. The net result is again a transfer of heat between the cylinder’s closures assuming the amount of heat, q, to be proportional to $K\,R\,S_A / v$ where S_A is the surface of lids with the emissive power K, piston diameter R and radiant heat velocity, $v\ (\equiv c)$. Consequently, *Bartoli* derived the relation for radiation pressure, $p = 2\,Q\,E / v$, where Q is the power received by the unit area and E is the mechanical equivalent of heat, enabling him to calculate the solar pressure to have the value $8.4\ 10^{-4}$ g/m^2 (which, however, was about 2000 times less than required to power a radiometer). Few years later, *Bartoli* gave up his original idea deciding that there is no light pressure after all.

The absolute validity of the second law of thermodynamics was for long a hot topic of discussion and particularly *Maxwell, Boltzmann or Loschmidt* concentrated on the principle necessary for a mechanical explanation, in general, not referring to particular processes such as radiant heat, which might violate the law. In 1882, the US astronomer *Eddy* argued in a thought experiment of a system of apertures distributed equidistantly around three concentric cylinders (‘*syren*’) that radiant heat (having presumably a finite velocity) could apparently be an exception. He evidently viewed his result as providing the support for the

Maxwell-Boltzmann hypothesis, which in *Eddy's* interpretation stated that '*the second law was merely the mean result emerging from the laws of probability'* and which was an escape from the pessimistic prediction of the prognoses of heat death of the Universe.

Boltzmann raised later critique against the details of Bartoli's process arguing by necessity to have to modify it to become reversible and adopted the assumption of radiation pressure as well as the validity of the second law of thermodynamics (implicitly rejecting *Eddy's* claim). He conveyed the relation $p(T) = (\pi/c)\ T \int \phi(T)\ dT/\ T^2$, where ϕ is the energy flux and T is the absolute temperature, and confirmed experimentally Stefan's Law of radiation energy in the form $p(T) = (\pi/3c)\ \phi(T)$ *and* $\phi(T) \approx\ T^4$. It literally followed *Maxwell's* old result written as $p(T) = (1/3)\ \psi(T)$, where ψ is the energy density. In 1893, *Wien* derived his displacement law by extending Boltzmann's reasoning [159] to cover the separate wavelengths of the blackbody radiation (scaling) so that $u_\omega = \omega^3\ f\ (T/\omega)$, where f is a universal function and ω is the frequency. Both these relations were temperature dependent so that at the absolute zero they would vanish, which would bring somehow 'disastrous' consequences on the stability of atoms factually leading to body's collapse [160].

Let us mention that any system is defined as being at absolute zero when no heat flow, Q, can occur out of the system during any reversible isothermal process performed on the system. Consequently, for the classical electromagnetic zero-point radiation process, only the nonzero spectrum is suitable for establishing an equilibrium state with the electric dipole oscillators at a temperature of absolute zero. This requirement ($Q=0$ and $T=0$) must also satisfy the third law of thermodynamics, i.e., the ratio of Q/T should also approach zero in the limit of $T \rightarrow 0$, which places a further restriction on the spectrum of incident radiation. Therefore, if a statistical equilibrium configuration is at all possible for a system of classical charged particles, then at a temperature of absolute zero must exist a zero-point classical electromagnetic radiation as well as a zero-point oscillating motion for the charges. Of course, zero-point field and motion are normally associated with quantum-mechanical systems and are alien to the traditional ideas of classical thermal physics. However, a qualitative way of understanding why zero-point fields and motion exist, should be a natural part of thermodynamic behavior of classically charged systems of particles, i.e., they *cannot* exist in a static, stable equilibrium. Hence, if an equilibrium situation for charged particles is at all possible, then the charges must be following a fluctuating, oscillatory path in space. The oscillating charges produce fluctuating electromagnetic fields, which in turn act upon these charges. Thus, any possible equilibrium situation must involve the presence of electromagnetic radiation, as well as an oscillatory motion for the charges, even at a temperature of absolute zero. All motion of charges would then possess a stochastic character. These qualitative ideas correspond moreover

to what we observe in nature when at the zero absolute temperature molecular activity does not cease but has a *zero-point* motion.

This has brought into serious consideration the concept of zero-point energy of electromagnetic field background, which was originally introduced into physics for the sake of consistency of experimentally observed spectral composition of the blackbody radiation with the assumption of discontinuous light emission [161]. In modern quantum electrodynamics, the zero-point energy arises rather from the non-commutativity of operators corresponding to the wave amplitudes of electromagnetic field [162]. The spectral distribution of the blackbody radiation, which conforms to this requirement, is represented by a complete Planck'*s* formula: $u_{\omega T} = (\omega^2/\pi^2c^3)\{\hbar\omega/[exp\ (\hbar\omega/kT) - 1] + \hbar\omega/2\}$. This formula consists of two additive terms, the first describing the purely thermal (i.e. conventionally temperature dependent) part of the blackbody radiation. The other one corresponds to the radiation surviving even at absolute zero temperature, down to the so-called zero-point radiation. Using homogeneity arguments, there is only one possible form of the spectral energy density, u_ω, which is Lorentz invariant; it reads as $u_\omega = (\hbar\omega^3/2\pi^2c^3)$. This relation, which describes isotropic zero-point radiation, has two significant properties: namely, it is Lorentz invariant and, in contrast to the temperature dependent term in the previous equation, its integral taken over all admissible frequencies is divergent.

Serious disadvantage of this formula is obviously due to its divergence with respect of the integration over the infinite frequency range. In order to obtain a physically more meaningful figure a rather laborious work with infinities and/or the introduction rather arbitrary cut-off frequency is required. Moreover, any macroscopic model of partitions involved in thermodynamic thought experiments with electromagnetic radiation should not a priori ignore their microscopic atomic structure without serious danger of introducing a bath by zero point radiation. Physically, the zero point radiation can be interpreted as a random, highly pervasive background field existing due to the incoherent vibrations of distant charges dispersed somewhere in and over the Universe. It is exclusively responsible for the quantum behavior of minute particles (often called 'Zitterbewegung'). Hence, the zero-point radiation ensures the stability of ordinary matter by precluding the devastating effect of the Coulomb interaction.

In this respect it worth noting that there exist the force between uncharged conducting surfaces, which is called '*Casimir force'* and which was described as one of the least intuitive consequences of quantum electrodynamics [163-168]. Casimir force per unit area equals to $\pi^2\hbar\ c/(240\ r^4)$, where r is the sub-micro-separation of two parallel plates and was derived as early as in the year 1948 [169] by considering the electromagnetic mode structure between the two parallel conducting plates of infinite extent in the comparison with mode structure when plates are infinitely apart by assigning a zero-point energy of $\hbar\ \omega/2$ to each electromagnetic mode (photon). The only inherent fundamental constants are $\hbar$ and *c,* while the electron charge, e, is absent, which implies that

the electromagnetic field is not coupled to matter. The role of the speed of light, c, is to convert the electromagnetic mode wavelength, as determined by *r*, to frequency, while the *Planck* constant, *ħ*, converts the frequency to energy. This Casimir effect results, thus, from changes in the ground-state fluctuations of a quantified field that occurs due to the boundary conditions. This was not predicted by the *London's* in his well-established calculation [170] made back in the year 1930, according to which the *van der Waals* unretarded forces arise directly from the *Coulomb* interactions between the molecules undergoing quantum fluctuations, yet later analyzed by *Boyer* [171] who reconstructed Casimir results for the energy change by proposing that the force between the plates arises from the zero point field subject to boundary conditions. It is worth noting that it has further followed the classical work by *Lifshitz* [172] on dispersion forces between dielectric bodies under field fluctuations.

It occurs for all quantum fields and it can arise from the choice of topology and is somewhat a current explanation of `vacuum` similarly to the Aristotelian `plenum`. It can be further extended to see the *Casimir`s* unsuccessful attempt to derive the fine-structure constant of the Universe by constructing an electron-based model upon the assumption that an electron is a sphere of uniform charge density, with its total charge equal to the electron charge and whose radius is determined by the balance between the attractive Casimir force (holding the electron together) and the Coulomb repulsion (tending the electron to expand). The effect of motion received attention in view of moving boundaries. An observer, who is in a uniformly accelerating frame could conclude that the frame (within the acceleration *a*) is reflected on the thermal bath of temperature $T = \hbar a/(2\pi ck)$. It calls attention to the acceleration, which promotes zero-point fluctuations to thermal fluctuations, similarly to the case, if the plates of the Casimir experiment are accelerated away from each other enabling thus the photons generation in the gap [173].