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THE CONCEPTS OF LIGHT AND VISION IN THE PREHISTORIC AND ANCIENT GREEK ERAS

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Since ancient times, light and vision have attracted the scientific curiosity of illustrious philosophers such as DEMOCRITOS, PLATO, EUCLID, ARISTOTLE, ARCHIMEDES, and more recently, DESCARTES, NEWTON, HUYGENS, FRESNEL, MAXWELL, EINSTEIN, and many others. All of these made a great effort to elucidate this difficult problem.

Up until the beginning of the current century, light was thought of as t h e c a u s e that brings about the stimulation of the sensory cells of the eye. Most of the classic works of Physics give this definition, which is far from being scientifically correct. PARINAUD, in his famous book „La Vision", states that light is a d e t e r m i n e d r e a c t i o n of the visual neural system caused by the vibration of a natural factor which we call ether. This definition, though more correct than the previous one, is still far from being complete.

According to data known today, light should be called the n o r m a l c e r e b r a l o u t c o m e that derives from the impact on the receptor cells of the retina, and further, on the whole cerebral visual system, of a fraction of radiating energy. It is

not correct to assume that the physical medium that causes a sensation of light – and that holds true for all the other sensations – is indentical with the final cerebral response.

Light, sound and the other sensations do not exist in the surrounding environment. If it were not for us to receive them, they would merely be waves of energy.

We therefore live in a dark and silent world, witnessing the incessant impacts of innumerable waves and radiations; of these waves, we are able to recognise only a minimal percentage – those which we are able to capture with our sensory organs, to decipher their message with our cerebral centers, thus transforming them into appropriate sensations. Therefore all sensations such as light, sound, smell, etc., are non-existant in the outer world, since they are created w i t h i n u s.

This basic truth has been supported since the Fifth Century B.C. by DEMOCRITOS, who wrote: „ . . . sweet and bitter, cold and warm, and all colours, are our own creations, not existing in the outer world. In the world surrounding us exist only unchanged molecules, atoms, and their motion in an empty space".

MAX PLANCK, twenty-five centuries later, repeated the same ideas, saying that „ . . . in nature there exist only elementary particles – without colour, taste or smell that stimulate the sensory organs and produce sensations that constitute the only real elements in the world . . ."

It is not hard to grasp the truth of what has just been said. Suffice to appreciate that all around us there exist thousands of waves emanating from applicances of human technology (radio stations, television, radar, wireless, etc.) as well as from cosmic or other sources about which we still know nothing. It is, however, certain that none of those radiations can be captured without the interposition of a special receiver that will gather it, process it, and transform it into pertinent material that will be fed to the brain, where the sensations of light, sound etc. are finally generated.

For more than four billion years the sun and other stars were in their orbits without shedding light on the earth, as is commonly believed. They started to shine only when somewhere on earth a living being was born, provided with special cells, able to capture the radiant waves of a certain wavelength emitted by the sun and stars. This energy, after special processings, was transformed into light, and thus vision was born.

Broadly speaking, vision dates back to the Paleozoic era. It is estimated that it appeared approximately 500 million years ago. This vision was very grotesque at the beginning, but after passing through many evolutionary stages, the creation of specialised cells came about. These cells were grouped together finally in the same place giving rise to the rudimentary eye receiver. Such an eye was to be found in the trilobites that lived in the Cambrian, Silurian eras, i. e. 400 million years ago.

After many years, the „inner eye" was formed, precursor of the human eye, that was able to capture part of the existing radiation, i. e. the light, process ist, codify it, and transmit it to the second part of the visual system – the visual sphere of the cerebrum, where the sensation of light would be formed, and that of colours and shapes also. The same evolutionary process took place for hearing, only much later during the Masozoic era, i. e. 200 million years ago.

And while we know almost nothing about the living being that first „created" light, we do know that the first animal to hear the noises of the earth, its own voice and the voices of other animals was the „Eryops" that lived in the carboniferous era. It seems that Eryops had also been endowed by nature in an extraordinary manner, in that it had three eyes; two on the side of the head and the third in the middle just over the frontal area.

After all that has been said, we may feel that ARISTOTLE was completely right in stating that:

„The mind is unable to conceive anything
without first sensing it."

The first reference to light is found in the Old Testament when God ordered „Let there be light". The Sumerians and Babylonians did not give a scientific explanation regarding the nature of light; the same is true of the Egyptians, despite the well developed mathematical knowledge and astronomical observations made by this people.

In early antiquity, the Greeks deified the sun and light, naming this deity „Apollo", who blessed mankind with warmth, but also was responsible for the disasters caused by his burning arrows. In this form, he was worshipped by the Greco-Pelasgians in their known territory, extending from the Tyrrhenian Sea to the Caucasus, taking a different name in each different country: Cataon, Syrius, Ioos and Lykios. In Homer, the God of Light kept many of the attributes of the God of the Pelasgic form, but he also became of a milder nature – extremely Greek, being called Phoebus, or Phoebus Apollo.

It is the Greeks that transformed the cunning God, son of Leto, who caused disasters into Phoebus Apollo – God of Wisdom and Music „the ever-young god, an example of youthful beauty, beloved by Zeus, who announced to mankind his immortal wishes through an infallible oracle" (KAROLIDIS).

This transformation of Apollo happened only in Greece, while in the Thracopelasgian world, he was worshipped exclusively as a god of light, exactly as in Egypt, where he was worshipped under the name of Horus.

The first written reference to light and vision in the preclassic period is found in the epic poems of Homer, where, for example, Thetis says of Achilles: „he owes his life to me and sees the sunlight" and further on, „and when the fleet-footed Achilles saw him, he recognised him immediately."

Such descriptions abound in the classical period in „Choiphoroi" of AESCHYLUS, „ . . . to see him near the light", and in „Oedipus" of SOPHOCLES, „ . . . so that neither I nor anyone else who sees light could be hurt", and in EURIPIDES „Iphigenia", „ . . . he who I want to see the light – no less than I do", an in many other Greek authors and poets, up to the point that the matter of light and vision is undertaken by the philosophers to be dealt with in a scientific manner.

The philosophers, however, insisting on elucidating whether sensations are the direct creations of external influences on the sensory organs or psychic manifestations caused by the transfer to the brain of those external stimuli, finally merely succeeded in complicating to an extreme degree all senses and especially that of vivion.

Homer called the eyes „radiant", and believed that vision is accomplished through rays of fine fire that is emitted by the inside of the eyes towards the objects seen, using the phrase „shots from the eyes". These concepts survived until the classical period without any serious criticism ever being expressed against them.

It must however be stressed that up until the classical period and afterwards until the Alexandrian period, not even one anatomical research was reported on humans, despite the advice of HIPPOCRATES who stated that „the great principle of medicine must be the knowledge of the body's constitution and make-up, that is, it's anatomy.

The first to perform anatomical research, but only on animals, is the Pythagorean ALCMEON (500 B. C.), and later on, probably also DEMOCRITOS. ALCMEON discovered the optic nerve and the tube that connects the middle ear to the pharynx, which is erroneously called the „Eustachian Tube" after Bartholomeo Eustachi, who discovered it for the second time two thousand years later. We think it right and more appropriate that the optic nerve be called „Alcmeon's Nerve", and the Eustachian Tube, „Salpinx of Alcmeon".

It seems that HIPPOCRATES never performed dissections. Wathever knowledge was possessed by the Asclepiads of his time on these matters was gained from the sacrifice of animals, and the study of the human body in the gymnasiums. For this reason, the knowledge of the human body was perfect regarding its external characteristics, while only rudimentary concerning details of its internal aspects and construction.

A small example of the ignorance of the Hippocratic physicians in their totally arbitrary teaching that the uterus is divided into two halves – in the right half they believed that males were conceived and in the left half, females.

Just as the knowledge of the body was imperfect, likewise the knowledge of the eye's anatomy was also incomplete. Hippocrates' people knew only what was offered to direct observation, that is, the sclera, known as „w h i t e o f t h e b u l b u s", the iris, and the pupil, known as „b l a c k". The cornea, which Hippocrates called „m e l a i n a" (also meaning ‚black'), and the physicians after him „c o r n e a". The point of union of the white of the bulbus with the cornea was called „i r i s" or „c r o w n". They ignored the existence of the lacrimal apparatus. It was much later that ARISTOTLE understood the communication between the conjunctival sac and the nasal cavity, when he observed that cosmetics applied to the eyelids and eyelashes were found in the nasal mucus. They also ingnored the lens, despite its obvious position in the vitreous. This was so because they believed that when the vitreous is frozen it becomes solid; when warm fluid – thus when frozen becoming like „transparent incense". This transparent incense was nothing else than the lens itself. The brain, deprived of obvious vessels, was regarded by Hippocrates as a gland. „the head has its glands also, the brain just like a gland . . . "

The Egyptians, who preserved their dead, kept their intestines in vessels placed around the sarcophagus, while they discarded the brain, extracting it through the left nostril. It is interesting to note that, while giving no importance to the brain, they never neglected to place a woman's statue in the vicinity of the dead person, in order that he would be able to continue the sexual functions!

It seems that the first to place sensations in the brain was Alcmeon, „ . . . the brain contains in welldefined areas the centres of the senses, including that of vision". Alcmeon also placed in the brain the mind, thought, memory, imagination and judgement – that is, man's intellect. Thus originates the ancient maxim: „The mind sees, and the mind hears". These ideas, however, although they were studied by the physicians and philosophers and those whom Aristotle called „physiologists" and „men of physics", were not accepted until 300 B. C., when the Alexandrian HEROPHILUS, performing dissections, even on live convicts, verified them.

HEROPHILUS studied the human anatomy in a systematic manner, especially the brain and the spinal cord, while also distinguishing between nerves and blood vessels, which were until that time confused. He discovered many anatomical regions in the central organ of the nervous system, the seat of the psyche and intellect, thus approving the ideas of Alcmeon.

A little while later, ERASISTRATOS (310–250 B. C.), the great supporter of Herophilus, enlarged upon them by making a distinction between the veins and

arteries, and defined the functions of the hearts's valves. Therefore, ERASISTRATOS may be thought of as the first explorer of the circulation of the blood.

And now, we believe that the ideas we have already referred to regarding the Hippocratic knowledge of the anatomy of the eye and brain are sufficient to enable us to deal with our main field of interest.

The first treatise on light is EUCLID'S „Optics" (330–270 B. C.). In this may be found the famous seven propositions, and among them the most noteworthy is that defining the size of the object seen. According to EUCLID, and, since then generally accepted, is that „the size of a seen object depends exclusively on the visual angle".

For those, however, not versed in Geometry, the same ancient beliefs, dating back to Homeric times, continued to be valid. According to these beliefs, vision was accomplished through „shots" originating from the „visual spirit that flows from the brain down the soft and hollow optic nerve and is ejected through the fluid sheaths of the eyebulb, finally reaching the object to be seen.

The Pythagerean School systematized the theory of visual fire, teaching that visual fire is created like vapours in the heart, reaching up to the foramina of the base of the skull, and entering the brain through them, where it is stocked in the lateral ventricles. From there, as the need may arise, it is conducted through the soft and hollow optic ligaments, i. e. the optic nerves, in the fluid sheaths of the eyebulb, from where it is ejected towards the object to be seen, similar to the light of a projector. Only those objects on which this visual fire falls are seen.

Alcmeon, as has already been said, placed the senses, including vision, in the brain, where whatever is projected is transformed into pictures, recognised, and the sense of vision is created.

According to EMPEDOCLES, the eye is a kind of lantern that emits rays, a theory already existing in Homer's time. For this reason a new concept arose: that in the pupil there exists fire and water; the fire is used to experience light and the water to experience darkness.

DEMOCRITOS, (460–370 B. C.), a near contemporary of Empedocles, condemned the theories of visual fire and supported the theory that light was a kind of energy, originating exclusively from outside the body. This energy derives from an ethereal substance that is emitted from the luminous as well as from the illuminated bodies. This energy leaves the objects, travels in a straight line in space, enters the eyes, is captured by them, and is finally led through the ligaments to the brain, where the picture of the object seen is created.

The theory of DEMOCRITOS, is almost identical to the modern theory of quanta because it allows the successive ejection of separate material particles, having the order and the size of the atoms emitted by the luminating source.

And so we come to ARISTOTLE, (384–322 B. C.) who accepted the „penetration of the rays of light from the outer world that enter the eye", but he refused to accept the material nature of light, Aristotle insisted that they were vapours from a body, dispersed at a given moment, striking the transparent fluids of the eye and creating the sensation of light and vision through their transmission to the brain. Aristotle was much more uncompromising than Democritos, and rejected altogether the theory of visual fire, and was a fervent supporter of the senses.

According to HELMHOLTZ, Aristotle may well be considered as the father of the basic ideas on waves. To him, light does not have a material nature, but is „energy" of the transparent medium found between the bodies. When this energy is in a state of quiescence, there is darkness; when in a state of oscillation, it causes the sensation of light.

A basic role in the conception of light and the other sensations is played by the sensory organs and the brain.

PLATO, (427–347 B. C.), who regarded vision as the dominant sense and called it the „most luxurious", tried to compromise the different opinions on light. Thus, while in the beginning, and especially in „Timaeus", he followed the ideas of Empedocles, supporting the bipartite nature of vision, in „Theaetitos", he approached Aristotle, while seeking to understand the influence of the intellect and the mind in general in the formation of the sense of light and the creation of vision.

According to Plato, the realization of vision requires that light coming from inside, the „v i s u a l f i r e", originating in the brain, and reaching the eyes, must unite with the light from outside, the „l i q u i d f i r e" that is emitted by the bright objects. If the particles of the visual fire are big enough to pass through the liquid fire, then the eye sees darkness. When the opposite occurs, that is, if the particles of visual fire are so fine as to become separated from those of the liquid fire reaching the eye, whiteness is seen. The different proportions of the size of these particles of visual and liquid fire give us the different colours, because of their different intensity and intermixing.

These purely hypothetical ideas about the nature of light, deprived as they were of the slightest experimental proof, had been accepted as valid all through the Alexandrian and Greco-Roman period without any criticism or effort to improve them, despite the significant contributions of the Alexandrian School in anatomy and physics. The first to give a complete anatomical description of the eye seems to be HEROPHILUS (300 B.C.). He described the retina, the vitreous, the ciliary body and also discovered much pertaining to the central nervous system, as previously mentioned.

However, ERASISTRATOS' contribution (310–250 B.C.) was of considerable importance, as, according to RIESE he founded the axiom „on the anatomical viewpoint of function and disease". He discovered the vascular sheath of the brain and named it choroid, giving the same name to the equivalent vascular sheath of the eye.

In this period the crystalline lens was discovered. We cannot be sure to whom this important discovery should be attributed, however, it is certain that the mathematician, CLAUDIUS PTOLEMY (2nd Century B. C.) thought of it as a biconvex lens and suspected its purpose without daring to express his opinion which was contrary to traditional knowledge of that time.

In order to complete the discussion on this matter, we must state that GALEN, with regard to the fusion of visual fire with liquid fire, supported the idea that their mixing took place in the space delimited by the posterior corneal surface and the anterior surface of the crystalline.

Here we must say that GALEN supported the idea that incoming fire was projected like a cone. These ideas, however, were not propogated widely and most people were ignorant of them. The ancient Greeks and the Greeks of the Alexandrian period continued to believe the Homeric ideas about light and vision: that is that light came out of the brain just like hearing, smell, even respiration – and it was ejected via the eyes on the object to be seen.

The views of Aristotle and Democritos were unknown, just as the anatomy of the eyes and brain continued to be unknown.

The abandonment of the experimental philosophy of the Ionian School and the consequential flourishing of scholasticism and imagination, led the ancient Greeks to explain light and vision with various hypotheses that were outright childish. VILLARD asks „How such intelligent people did not think of making some elementary experiments that would make them understand the physiology of vision?" Buth neither observation was carried out in a proper manner. Excluding Alcmeon, Epicurus, Herophilus and Erasistratos, all the other wise men of Ancient Greece were solving the problems of physics and physiology with theories and hypotheses that were often naive. Experiments, observation and correct thinking were means that were left unutilised; imagination was the only basis on which explanations of natural phenomena were founded. This fact led Greek thought to scholasticism and metaphysics. Here follows an example found in Galen: „The spirit that descends from the brain and is distributed to the eyes – if one eye were destroyed, it would reach the other eye intact" Further on, without being the slightest doubtful of his ideas, Galen writes: „ . . . when the one eye is closed, we can see much better since the power that previously was distributed to the two eyes is now concentrated only in one".

Despite EUCLID'S contribution with his work „Optics", in spite of the discovery of the lens and PTOLEMY'S suspician about the refractive role played by the lens in vision, no progress in the anatomy of the brain and the eyes was made by the Alexandrian School. This is so because Greek thought, after reaching its climax in the first Alexandrian period, suffered a sudden decline after Euclid's death and especially after the killing of the great ARCHIMEDES (257–212 B.C.) by the conquering Romans, who had set as their sole target to conquer the world as they knew it then, and to exploit it to their own advantage. They despised medicine and the natural sciences, considering them devoid of interest for a war minded nation such as they were.

APOLLONIUS (170 B. C.) tried in vain to hold things in place. Greek science was sinking deeper and deeper into mysticism and magic with unending and illogical hypotheses; as has been already said, imagination was the essence of all sciences. By the second Alexandrian period, judgement, observation and logic had altogether vanished. For example the Alexandrian GLAUCIUS, highly esteemed as a doctor, and having many followers, supported the idea that when two diseases present the same clinical characteristics, they should be treated with the same drugs. It follows that drugs used to treat diarrhoea should be administered to treat hemorrhage since the common clinical characteristic of both conditions is the „flow".

And so we come to the Roman times, and although we cannot deny their civilisation, it must be remembered that with the Romans came a decline in the scientific fields, especially that of medicine, which previously had been the dominant science.

A confusion between the different ideas and theories continued for many years in the c o n c e p t i o n o f l i g h t a n d v i s i o n until the progress of anatomy and physiology aided by mathematics and physics was achieved during the following centuries, giving to this field of science the extension of knowledge existing today.

Summary

There is a similarity of ideas between ancient philosophers and modern scientists concerning the definitions and understanding of light and vision. The authors report the history of the development of the concepts concerning light and vision throughout the ages, from the Paleozoic Era and the mythological period on. They give special attention to the ancient Greek civilization, describing the views of its philosophers and scientists, such as Alcmeon, Democritos, Hippocrates and Aristoteles, as well as the concepts of the Pythagorean School and Euclid. Finally, the ideas of Plato and the teaching of the Alexandrian School, the Herophilus anatomical descriptions of the retina and other parts of the central nervous system and the contribution of Erostratos are discussed. The authors complete their report with Galen's opinion and description leading to the "dark ages" precipitated by the rise of the Romans. In conclusion, they stress the confusion which existed between the various theories throughout the ages concerning the conception of light and vision.

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DJAKOS K. et FRONIMOPOULOS J. – Les conceptions de lumière et de vision dans l'ere Grecque préhistorique et ancienne

Resumé

Il y a une certaine similarité d'idées entre les anciens philosophes et les scientistes modernes en ce qui concerne les définitions et la conception de lumière et de vision. Les auteurs rapportent l'histoire du développement de ces concepts à travers les âges depuis la periode paléozoïque et la période mythologique. Ils accordent une attention particulière à l'ancienne civilization grècque, en donnant les idées des philosophes tels que Alcmeon, Démocrite, Hippocrate et Aristote, ainsi que les conceptions d'Euclide et de l'école de Pythagore. Finalement les idées de Platon et l'enseignement de l'école d'Alexandre, les descriptions anatomiques de la rétine et d'autres parties du système nerveux central par Hérophile et les contributions d'Erostrate sont discutées. Les auteurs complètent leur rapport avec l'opinion de Galien conduisant aux "années sombres", précipitées par l'ascension des Romains. En conclusion, ils mettent l'accent sur la confusion qui existait entre les différentes théories à travers les âges en ce qui concerne la lumière et la vision.

DJAKOS K. und FRONIMOPOULOS J. – Die Auffassung von Licht und Sehen in der vorgeschichtlichen Zeit und bei den alten Griechen

Zusammenfassung

Es besteht eine gewisse Ähnlichkeit zwischen den Ideen der alten Philosophen und der modernen Wissenschaftler, was die Auffassung und Definitionen von Licht und Sehen angeht. Die Autoren rekapitulieren die Geschichte der Entwicklung dieser Auffassungen durch die Zeitalter hindurch seit dem Paleozoikum und dem mythologischen Zeitabschnitt. Sie widmen der alten griechischen Zivilisation eine besondere Aufmerksamkeit und geben die Ideen der Philosophen wie Alkmeon, Demokrit, Hippokrates sowie die Auffassung Euklids und der Pythagoräischen Schule wieder. Schließlich werden die Ideen Platons und die Anschauung der Schule Alexanders, die anatomischen Beschreibungen der Retina und anderer Partien des Zentralnervensystems von Herophiles und die Beiträge des Erostrates diskutiert. Die Autoren vervollständigen ihren Bericht mit der Meinung von Galen, die zu den „dunklen", durch den Aufstieg der Römer beunruhigten Jahren führt. Abschließend heben sie die Verwirrung hervor, die unter den verschiedenen Theorien über Licht und Sehen im Laufe der Zeit bestand.

DJAKOS K. y FRONIMOPOULOS J. – El concepto de luz y visión en la era prehistórica y antigua griega

Resumen

Hay una cierta similitud de ideas entre los antiguos filósofos y los sabios modernos en lo que concierne a las definiciones y la concepción de luz y visión. Los autores narran la historia del desarrollo de estos conceptos a través la eras, desde el período paleozóico y el período mitológico. Ellos prestan una atención particular a la antigua civilización griega, dando las ideas de los filósofos como Aristóteles, Demócrito, Hipócrates y Alcmeón, así como las concepciones de Euclides y de la escuela de Pitágoras. Finalmente las ideas de Platón y la enseñanza de la escuela de Alejandro, las descripciones anatómicas de la retina y otras partes del sistema nervioso central por Herófilo y las contribuciones de Erostra son discutidas. Los autores completan su relato con la opinión de Galien que conducen a los años sombríos precipitados por la ascención de los romanos. En conclusión, hacen la remarca sobre la confusión que existía entre las diferentes teorías a través las épocas en lo que concierne a la luz y la visión.

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