———— 1990b. Archaeopteryx and science. *Bible-Science Newsletter* 24(10):3.
Beardsley, T. 1986. Fossil bird shakes evolutionary hypotheses. *Nature* 322:677.
Pearcy, J. R. 1985. Archaeopteryx and the gang of three. *Bible-Science Newsletter* 23(9):3.
Pilbeam, D. 1974. Size and scaling in human evolution. *Science.* 186:892.
———— 1978. Rearranging our family tree. *Human Nature.* June:45.
Ridley, M. 1981. Who doubts evolution? *New Scientist* 90:830-1.
Watson, L. 1982. The water people. *Science Digest* 90(5):44.
West, R. 1988. Paleontology and uniformitarianism. *Compass* 45:216

Contributed by David A. Kaufmann

*Editor's Note: Two other recent references on Archaeopteryx are listed below.

Astles, K. 1986. Archaeopteryx: a cross-bird puzzle. *Creation Ex Nihilo* 8(3)40-5.
Clausen, V. E. 1986. Recent debate over Archaeopteryx. *Origins* 13(1):48-55.

CONVERGENT EVOLUTION— DO THE OCTOPUS AND HUMAN EYES QUALIFY?

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Abstract

The eyes of the higher Cephalopods particularly those of the octopus, are compared with the human eye to try to determine whether they are legitimate examples of that rather vague, innocuous evolutionary principle of convergence. Some similarities and differences are explored with the conclusion that in the created order we observe similar over-all blue prints being used for similar purposes, with the necessary modifications for special conditions and/or environments, the eye of the octopus and that of man being one example.

Convergent Evolution

One of the directions of the postulated organic evolutionary process is what is termed convergent evolution. In general this can be defined as a process by which nature achieves comparable results by travelling along entirely different routes. Stated more specifically, organisms that are not related, or only distantly so, living in similar environments, eventually develop similarities in certain of their organs or bodily structure. Dobzhansky (p. 744) defines convergent evolution as follows: "Convergence is the evolution from different ancestors of organisms similar in appearance and in ways of life."

One of the classic examples of this concept, often appearing in evolutionary literature, is the comparison of the eye of one of the higher invertebrate Cephalopods, usually the octopus, with the vertebrate human eye. Two illustrative quotes are as follows, the first being from a recent issue of *Creation/Evolution.*

> Biologists can cite many instances of parallel evolution (should be convergent evolution, HSH) in which forms that are only distantly related have developed similarities in structure—for example the almost identical structures of human and octopus eyes. (Albert, p. 28)

Cousteau and Diole (p. 88) contribute the following: "The eyes of Cephalopods are almost the equal of those of men. Their eyes like vertebrates have lids, irises, crystalline lenses and retinas."

Patterns of Animal Vision

Vision in the animal kingdom is probably its most valued sense, even if a variety of species depends to a greater extent upon others, such as smell and hearing. See Hamilton, 1985. Vision, of course, is mediated by the eye in association with the central nervous system, both of which are found in nature varying from the very simple to structures of extreme complexity and organization, as in the higher vertebrates. The eye, with its almost infinite variations in design, particularly in the invertebrates, has always presented a grave problem to the evolutionist in his attempt to forge an evolutionary series where none exists as pointed out by Duke-Elder: "The curious thing, however, is that in their distribution the eyes of invertebrates form no series of contiguity and succession." (p. 178). Any positive evidence of evolution of the vertebrate eye from the invertebrate is totally lacking as well.

The most efficient kind of vision is attained when external objects can be imaged on the retina of the eye in such a way that they can be accurately interpreted by the central nervous system of the organism. Two effective methods of doing this are found in nature. One classification is the compound eye of insects which is made up of many small units (ommatidia), each one contributing a small section of the visual field. The other classification is termed the simple eye, the gamut of which ranges from a simple surface "eyespot" to an organ where light is received into the more or less rounded cavity of the eyeball, and, in its most advanced state, brought to a focus on the light-sensitive retinal layer which lines about 2/3 to 3/4 of its posterior surface, thus resembling, in principle, a camera. In the invertebrates the most highly developed such organ is found in squids and octopi among the Cephalopods. Since in most of the literature the higher Cephalopods are usually represented by the octopi, this discussion will be limited to them.

The eyes of vertebrates with very few exceptions are modeled on the second type, as above, in its complex form. There are many variations in the vertebrate model in size, shape, mode of focusing (accommodation), retinal structure and other details, but the basic principle is almost universally followed. A minor exception, the Apoda, constitute a small

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group exhibiting rudimentary and degenerative eyes. Man, with his vertebrate type of eye and associated three pound brain, which has been described as the most highly organized moiety of matter in the universe, stands at the apex of the total visual faculty.

Invertebrate Eyes

Two main types of eyes are found in invertebrates, simple and compound. The latter are peculiar to the Arthropods and do not concern us here. The simple eye varies from an eyespot on the surface epithelium in unicelluar organisms to those of the multicellular Cephalopods, with eye of the *Ottopus vulgaris* being representative of the highest development. Intermediate forms consist of a group of associated light-sensitive cells on the flat surface, then a dimpling of these cells, which in higher forms appears as a definite cup with a small hole, as in the Cephalopod Mollusc, Nautilus, thus acting like a pinhole camera. A further differentiation occurs when the hole closes, thus separating and isolating the cavity from the surface. The cells lining it are of two types, one being secretory and filling the cavity with a clear material, with the other, being light-sensitive, forming a primitive retina. Such an arrangement, of course, is non-image forming and is seen in Gastropods. Finally, the necessary mechanisms to produce images are found in the higher Cephalopods, consisting of the addition of a lens and a method of accommodation to produce an adequate image on the light-sensitive cells lining the posterior of the cavity.

It will be noted that all these variations in form originate by an invagination of the surface epithelium. A succession of organisms can thus be posed that exhibits these different styles of the simple eye, but such a series in no way confirms that a more complex form evolved from a less complex one. Each organism appears to have been endowed with visual abilities in accordance with its basic requirements, but a few appear to possess visual competence beyond obvious needs. Since the octopus is an active creature, inhabiting the rock crevices and swimming with considerable speed, its eyes would, of necessity, have to be capable of a considerable degree of visual discernment. Such would require an image-producing eye of some complexity with a lens and an accommodative mechanism. It therefore has an eye designed to satisfy these needs.

Vanadis

As an interesting sidelight to this discussion, the lowly deep sea worm, *Vanadis,* also has an eye with a lens and probably some accommodative abilities but the detailed physiology has not been completely worked out. It has an accessory retina far forward, almost alongside the circular lens, discrete from the main retina, which latter, as is the rule in invertebrates, is verted in type (Figure 1). Interestingly enough, an accessory retina also occurs in the tubular eyes of some deep sea fish and deep sea Cephalopods. Here it is the continuation far forward of the normal retina from the latter's usual termination and is not a separate part as in *Vanadis.* The octopus does not have an accessory retina. Wald and Rayport (p. 1439) conducted electroretinogram studies on *Vanadis* eyes which revealed that the retinas were most sensitive to the wavelengths of light which penetrate to the depths of the worm's habitat.

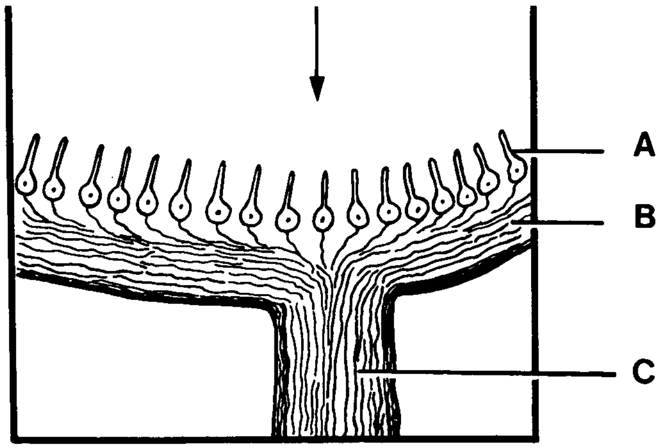

Figure 1. Invertebrate Retina (Verted). Arrow indicates direction of light. A: Light sensitive cells. B: Nerve cell fibre layer. C: Optic nerve.

Octopus Versus Human

When considering the evolutionary concept of convergence with regard to the eyes of octopi and humans it would be of interest to point out just how much similarity there is as well as some of the major differences between them. It is not possible in a short article to mention many of the finer details but only those which are the most obvious. As stated previously the simple eye of invertebrates, with few exceptions, is derived from the surface epithelium, whereas in vertebrates the tissue of origin is the neural ectoderm. Thus the eyes of vertebrates and invertebrates originate from different sources (Duke-Elder, p. 115). We would therefore expect to find differences in structure and function.

The only similarities between the two eyes are that they are both image-producing, thus requiring a cornea, iris, lens and retina, but here the similarities end, as the individual structures differ quite markedly, both anatomically and physiologically. As mentioned previously the worm, *Vanadis,* also has these same components, but, like the octopus, its counterparts little resemble those of the human.

The octopus eye is enclosed in a fibrous and cartilaginous casing whereas the human eye lies in a bony socket. Four extra-ocular muscles move the octopus eye whereas the human has six. Due to the configuration of the head and position of the eyes in the octopus there is very little overlapping of the visual fields, resulting in the head being tilted sideways as it uses one eye in approaching an object (Wells, p. 258). Humans, of course, have binocular vision, a necessary requirement in the execution of fine hand movements and other activities. The preponderance of evidence suggests that octopi lack color vision. (Wells, p. 209).

Cornea

In the Cephalopods the state of the "cornea" is variable in that in some species a hole is present enabling seawater to circulate in the anterior chamber (Figure 2). In others there is no hole. Duke-Elder (p. 144) describes it this way:

> . . . the transparent surface epithelium forms a "cornea," sometimes in Myposidae, forming a continuous layer in which the cul-de-sac (the "anterior chamber") is filled with an "aqueous humour" (cuttlefish, *Sepia;* squid, *Loligo),* sometimes in Oegopsidae, perforated by a hole so the cavity is flushed with seawater (Octopus),

Any perforation of the human cornea from whatever cause can, of course, be disastrous. In contradistinction to the human, the cornea of the octopus, being a sea dweller, takes no part in the refractive process which is done entirely by its lens.

Iris

There are differences in the irides of the octopus and man. That of the octopus, unlike man, is covered by a silvery membrane which glitters and shines like mother-of-pearl (Duke-Elder, p. 145). The pupillary aperture in man is round whereas in the octopus it is more or less rectangular, and, in contraction, forms a narrow horizontal slit. Such a contracted pupil presents problems with astigmatism, which is not the case with a round pupil. In the human a circular muscle embedded in the iris at the pupillary margin contracts it, while radiating fibres therein cause dilation. Both pupils react in unison whereas in the octopus no dilator muscle has been definitely demonstrated, and the irides are not under unified control but can function independently (Wells, p. 152).

Lens

As shown in Figure 2. the lenses of the cephalods are composite, being formed partly from vesicular epithelium and partly from surface epithelium, as compared with a homogeneous lens in man. In vertebrates and man the origin of the lens is not definitely known and is disputed (Duke-Elder, p. 246). In the octopus the lens is round and firm whereas in the human it is oval and pliable up to about the middle teens at which time it slowly begins to stiffen, and is entirely so at about 55-60 years of age.

Accommodation

The processes of accommodation (focusing) in the octopus and man are entirely different. In man the corneal curvature is a factor in refraction whereas it is not so in the octopus. In man the alteration of the lens curvature by the action of the ciliary muscle, and the inherent elasticity of the lens itself, together with the refractive influence of the corneal curvature direct light from near and far to a focus on the retina.

Since the rigid lens of the octopus cannot change its shape in order to focus light on the retina, its position in the eye has to be altered. This is accomplished by the contraction of the ciliary muscle which displaces the lens backward. Movement in the opposite direction is attained by the squeezing action of muscles exterior to the sclera increasing the intra-ocular pressure which pushes the lens forward. Wells (p. 151) states that this double focusing system has no parallel among vertebrates. While not exactly the same, the eye of the snake, which is unique among vertebrates (Hamilton, 1987) in possessing a brille or spectacle, has a lens which is displaced forward in accommodation by a similar increase in intra-ocular pressure (Duke-Elder, p. 596). Some fish also focus by lens displacement, but in these cases movement forward and backward is accomplished by small muscles attached directly to the lenses themselves.

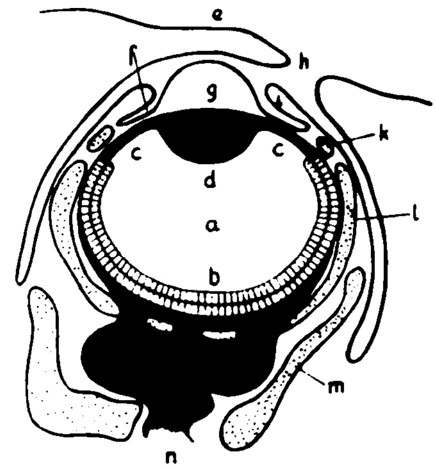

Figure 2. The eye of a typical cephalopod. Invaginated epithelium forms the optic vesicle *(a)* lined by the retina *(b)*, the posterior layer of the "ciliary body" *(c)*, and the posterior part of the lens *(d)*. The surface epithelium forms the cornea *(e)*, the anterior part of the ciliary body *(f)*, the iris *(i)*, and the anterior part of the lens *(g)*, a hole *(h)*, being left at the point of invagination. The eye is surrounded by a cartilaginous orbit, formed by an anterior cartilage *(k)*, an equatorial cartilage *(l)*, and an orbital cartilage *(m)*. *n* is the optic nerve. Reproduced by permission from Duke-Elder, Sir Stewart 1958. The eye in evolution in *System of Ophthalmology,* Volume 1. C. V. Mosby Co., St. Louis. (1986).

Retina

The major anatomical difference between the octopus and human eye lies in the retina, that of the former being very simple compared to the latter. The octopus retina has but one layer composed of essentially identical light-sensitive retinula cells which differ markedly from human rods and cones (Wells, p. 142).

In the human retina the sentient rods and cones anastomose with the middle layer bipolar cells, which in turn connect with the ganglion cells, interspersed with laterally oriented amacrine cells, the whole forming a virtually indescribable maze of links, junctions and relays. The afferent fibers from the ganglion cells come together in the eye to form the exiting optic nerve which, in conjunction with the optic radiation, leads to the visual cortex of the brain where interpretation takes place.

Lying behind the octopus eyeball, and separate from it, is the optic lobe, which contains two relays, somewhat comparable to the bipolar and ganglion cells in the human retina, leading to the cerebral ganglion of the nervous system, Figure 3. Wells states (p. 156) that there is no direct evidence about the function of any of the anatomically distinguishable cell types in the optic lobes, but their arrangement may have something to do with the analysis of visual images. The light-sensitive retinula cells of the octopus are verted as is the rule in invertebrates whereas the rods and cones in the human eye are inverted following the established major positional difference between the light-sensitive cells of invertebrates and vertebrates. (Figures 1 and 4). The octopus lacks a

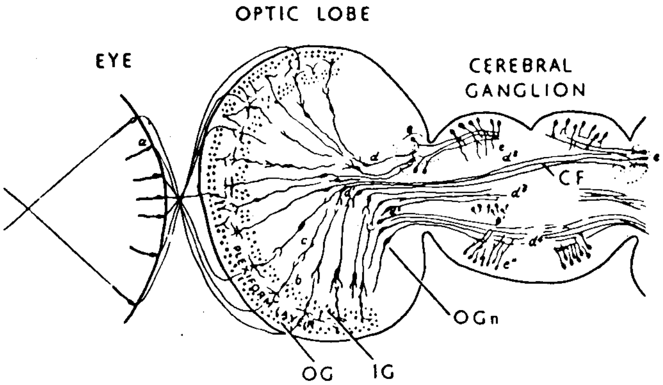

Figure 3. Diagrammatic scheme of the visual paths and their central connections in the cephalopod (after Kappers). Axons from the visual cells in the compound eye, *a*, decussate to form a chiasma and enter the optic lobe, terminating in the plexiform layer between the inner, IG, and outer granular layers, OG. The pathway is continued by axons of the granular cells, *b*, sometimes with an intercalated neurone, *c*, to the central and pedunculate nuclei of the optic ganglion, OGn. Thence a further relay, d^1 to d^4, continues the pathway to the cerebral ganglia to terminate in association areas, *e*, and, by means of commissural fibres, CF, in the contralateral optic lobe. Reproduced by permission from Duke-Elder, Sir Stewart. 1958. The eye in evolution in *System of Ophthalmology*, Volume 1. C. V. Mosby Co., St. Louis. (1986).

specialized area such as the fovea centralis which subserves acute central vision in the human.

Conclusion

The observation that there are certain similarities between the eye of the octopus and the human eye, but totally disregarding the many differences in individual structures, is said to be an illustration of the principle of evolutionary convergence.

Taking into consideration the activities and habits of the octopus, its needs for visual discrimination and perception would be best realized by an eye constructed on the principle of the camera. It is entirely appropriate therefore that *Octopus vulgaris* has been endowed with an eye of this nature designed to function in a watery environment.

Since there is no real evidence of ocular evolution among the invertebrates or evolution of the vertebrate eye from that of any invertebrate, it would be entirely reasonable and justifiable to conclude that each of these eyes under consideration was designed by some overarching Intelligence to satisfy its specific visual needs including the differing structural details necessitated by the two differing environments.

It seems incomprehensible to conceive that a non-teleological, chance process such as natural selection

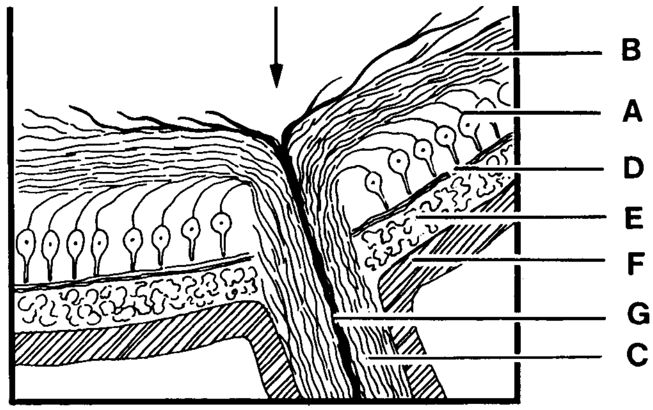

Figure 4. Vertebrate Retina (Inverted). Arrow indicates direction of light. A: Light sensitive cells. B: Nerve cell fibre layer. C: Optic nerve. D: Pigment cell layer. E: Vascular choriod. F: Sclera. G: Central retinal artery.

acting on almost totally regressive mutations could initiate the genetic information and direction necessary to fashion an image-producing eye in all its complexity even once, let alone twice, from different tissues, and in two models differing in physiological and anatomical detail, one in a water-dwelling invertebrate and the other in a vertebrate functioning in air.

From the anatomical and physiological evidence presented concerning octopus and human eyes it would appear that organic evolution would have to surreptitiously smuggle in a "watchmaker" as tacitly implied by Robert Ardrey and quoted by Macbeth (p. 132) in order for the concept of convergence to have any real significance.

References

CRSQ—Creation Research Society Quarterly

Albert, L. H. 1966. Scientific creationism as a pseudoscience. *Creation/Evolution* 6(2):28-34.

Cousteau, J. Y. and Philippe Diole. 1973. Octopus and squid—the soft intelligence. Doubleday and Co., Inc. Garden City, N.Y.

Dobzhansky, T. 1976. Evolution. Encyclopedia Americana, Volume 10. Americana Corporation. New York.

Duke-Elder, Sir Stewart, 1958. The eye in evolution in System of Ophthalmology, Volume 1. Henry Kimpton. London.

Hamilton, H. S. 1985. The retina of the eye—an evolutionary road block. *CRSQ* 22:59-64.

Hamilton, H. S. 1987. The snake's spectacular spectacle. *CRSQ* 23:177-8.

Macbeth, N. 1971. Darwin retried. Gambit Inc. Boston.

Wald, G. and Stephen Rayport. 1977. Vision in annelid worms. *Science.* 196:1434-9.

Wells, M. J. 1978. Octopus-physiology and behaviour of an advanced invertebrate. Chapman and Hall, London.

QUOTE

Computerized knowledge already may have begun to choke the springs of imagination. Of course it is not merely the device called the computer that works this mischief: rather, it is the mentality of the dominant Knowledge Class, one of whose instruments the computer is. Damage to the imagination—whether we call that mysterious faculty serendipity or intuition or the illative sense—may extend to many other fields than radio astronomy. It may extend to attempts at renewal of the person and of the Republic—to the life spiritual and the life temporal. If so, the wicked things written on the sky may be graven upon tablets of stone and set amongst us for our obedience to the commandments of the Savage God.

Kirk, Russell. 1985. The wise men know what wicked things are written on the sky. *Modern Age* 29:116.