INVITED PAPER

THE RETINA OF THE EYE — AN EVOLUTIONARY ROAD BLOCK

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Received 16 August 1984; Revised 1 February 1985

Abstract

This paper relates to the marked differences between the eyes of invertebrates and vertebrates with particular reference to retinal function and structure, the latter accentuating grave problems in their supposed evolutionary development. In image-producing eyes (Cephalopods and vertebrates) the exceedingly unlikely occurrence of two distinct and structurally contrasting retinas evolving by any non-teleological chance process is discussed. From the material presented it is concluded that omniscient Intelligence has designed and created the organs of vision as we encounter them in living organisms.

Introduction

In Genesis One it is recorded that the first "let there be" in God's series of creative acts resulted in the phenomenon of light. From this primary appearance, the importance of light in Creation and all that followed can readily be appreciated. Without light as we know it, our world would not be possible, as it is the energizing force in photosynthesis and it enables us to be aware of, and appreciate, the beauties of God's Creation. Its physical nature, whether a wave motion or a stream of particles, or both, need not concern us here. We are particularly interested in the process of vision, which, in the absence of light, is not possible.

Our eyes, along with the visual pathways to the visual cortex of the brain, mediate the sense of vision. Life, of course, is possible, even if the faculty of sight has been lost through disease or accident, but most people value their visual sense above all others, as about 38 percent of our total sensory input comes to us through our eyes.[1] As our intellectual development and general behavior are largely determined (in the absence of congenital defects) by our total visual faculty, the supreme importance of the latter is very evident. Although in many species the other senses, such as smell and hearing may and do take preference, the importance of the vertebrate eye, as well as in most invertebrates, but not all, is out of all proportion to its size relative to the rest of the body. With it, assisted by optical instruments, man has attempted to probe the secrets of the starry heavens and the extremely minute.

The eye has occupied a prominent place in men's thoughts from the earliest times. This is shown by its depiction in early hieroglyphics, wall paintings, and by such appellations as the evil eye, with the latter implying the possession of strange and mysterious powers. References to the eye appear in early civilizations with priority possibly belonging to India. Hammurabi (c. 1900 B.C.) in his code, prescribed penalties for unsuccessful treatment of certain eye disorders.[2] The ancient Egyptians contributed ideas also, but it was left to the Greeks to begin to fathom some of the mysteries of vision. About the time of Hippocrates (c. 460-357 B.C.) it was thought that derangements in health could possibly be due to innate physical changes in the body rather than being attributed to external supernatural influences. This spurred efforts to discover the form and function of the various bodily organs, including the eye. Through succeeding centuries various theories of vision were propounded and functions suggested for different parts of the eye as they were identified. It was not until the 14th century that the retina lining the back of the eye was definitely established as the essential organ of vision, functioning as a screen for the image. With the invention of the ophthalmoscope by Helmholtz (1821-1894), for the first time permitting the examination of the interior of the living eye, progress was rapid. Further development of instrumentation enabled the minute anatomy of the eye and the basic functions of its various parts to be elucidated, although there still remain numerous unanswered questions. The eyeball really exists as a housing for its most delicate and complex part, the retina, which will be my concern here.

In surveying the different types of eyes in the animal kingdom it is convenient to separate them into two divisions, the invertebrates and the vertebrates. In each division there is an almost limitless array of organisms to consider, but in only a relatively small number have detailed examinations of the eyes been made. However sufficient representation allows us to arrange the basic types of eyes in adequate classifications to try to determine if there is any evidence for an evolutionary succession.

Invertebrate Vision

The first fact to emerge from a general survey is that in the invertebrates there is tremendous variety in organs and mechanisms subserving vision, whereas in vertebrates the basic eye pattern is unchanged throughout. In both classifications the design and complexity of the organs of vision are commensurate generally with their needs, although there appear, especially in the invertebrates, to be numerous exceptions to this observation, with the visual efficiency of some seeming to considerably outweigh their projected requirements. Sir Stewart Duke-Elder in volume one of the classical 15 volume *System of Ophthalmology* makes this comment:

> The curious thing, however, is that in their distribution the eyes of the invertebrates form no series of contiguity and succession. Without obvious phylogenic sequence, their occurrence seems haphazard; analogous photoreceptors appear in unrelated species, an elaborate organ in a primitive species, or an elementary structure high in the evolutionary scale, and the same animal may be provided with two different mechanisms with different spectral sensitivities subserving different types of behaviour.[3]

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An example of an elaborate organ in a primitive species is the eye of the Cubomedusan, *Charybdea*, a kind of jellyfish, which has a large cellular lens, a vitreous structure and a complex retina which would theoretically be capable of a degree of imagery. Duke-Elder states, "The biological value of this elaboration in a brainless organism is somewhat speculative."[4]

The latter part of the quote is illustrated by the diving whirligig beetle which has two compound eyes on each side of its head, one above the other, the upper one being for aerial vision and the lower for use underwater when searching for food.[5]

In the simplest one-celled organisms, such as the amoeba, there is generalized sensitivity to light. In the Flagellata and Ciliata this generalized sensitivity is concentrated in an "eye spot" usually near the front end of the organism in association with the mechanism of locomotion. In these primitive eyes, of course, no images can be formed.

Concerning the origin of the Metazoa, G. A. Kerkut writes as follows:

> What conclusion can then be drawn concerning the possible relationship between the Protozoa and the Metazoa? The only thing that is certain is that at present we do not know this relationship. Almost every possible (as well as many impossible) relationship has been suggested, but the information available to us is insufficient to allow us to come to any scientific conclusion regarding the relationship. We can, if we like, believe that one or the other of the various theories is the more correct but we have no real evidence.[6]

In the invertebrate members of the Metazoa, all of which lack a dorsal nerve cord with its associated bony axis, there is an almost unlimited variety in size, shape and form. Included are the Coelenterata (hydra, jellyfish, etc.); Echinodermata (starfish, sea urchins, sea cucumbers, etc.); Platyhelminthes and other worm phyla, segmented and unsegmented; Mollusca (clams, scallops, etc.); the very large Arthropoda phylum (shrimp, lobsters, centipedes, spiders, crabs, mites, etc.) and in this phylum the large class of insects with numerous orders.

The eyes in this large invertebrate Metazoan group fall into two general divisions, simple and compound. The simple eye (ocellus) is characterized by a single light sensitive surface cell, as seen in worms. A further stage appears when we find a group of these cells aggregated together, although not connected, at either end of the organism. In the earthworm the light sensitive cells are associated with a network of nerves immediately under the surface, producing a further degree of efficiency, although still very primitive.

As we encounter organisms of increased organization and complexity but still in the simple eye category, we find a "sinking in" of the surface light sensitive cells to form a shallow depression or cup. With deeper sinking from the surface, and a closing over of the latter with the exception of a small hole, a primitive type of pinhole camera is formed, an example being the Mollusc Nautilus. In the polychaete worm, *Nereis*, the hole closes. A further refinement takes place when the completed cavity becomes totally separated from the surface layer, forming a vesicle. In all these arrangements the light sensitive cells line the back of the cavity like a primitive retina, but, as yet, there is no real intraocular structure to focus light sharply upon it. From the light sensitive cells of the retina, nerve fibres accumulate together into a nerve trunk which leads directly to the cerebral ganglia. The term "verted" is applied to this arrangement of the light sensitive cells and their afferent nerve fibres. (Figure 1).

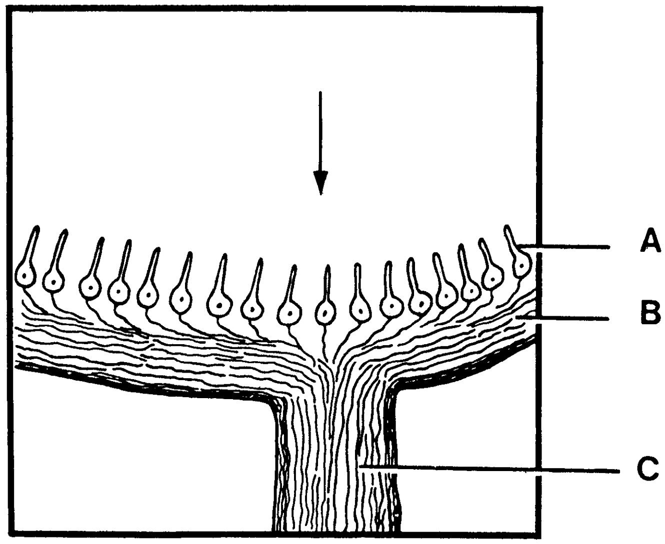

Figure 1. Invertebrate Retina (Verted). Arrow indicates direction of light. A: Light sensitive cells. B: Nerve cell fibre layer. C: Optic nerve.

Examples of the vesicular eye, with the addition of a lens, whose origin remains an enigma,[7] plus an extraocular muscle system to move the eye in various directions, are found in two different phyla. These are, among the Polychaetes in the family of Alciopidae, and among the Cephalopods (cuttle fish, squids and octopi), the latter having the most elaborate eyes in the simple eye category among the invertebrates. In the former, the eye of the Polychaete worm, *Vanadia*, has a lens and a vitreous cavity with a retina of the verted type, but it is not nearly so refined as the eye of the octopus, which, of all the invertebrates, most nearly resembles a vertebrate eye in its structure. The octopus has a cornea, ciliary body, iris, lens, vitreous and retina, and is capable of image formation of some degree, although overall quite inferior to the vertebrate eye. Its light sensitive cells and their connections with the animal's nervous system via the optic nerve retain the typical verted anatomical plan of the invertebrates.

Due to the invertebrates' comparatively simple ocular structure and their degree of visual acuity not requiring it, complicated mechanisms of accommodation (focussing) would not be expected. To make up for this lack, alternate methods are found in some species, for example, different static eyes in the same organism, one for near and one for distance (median and lateral ocelli of spiders), or different optical systems in the same eye (grasshoppers).

On the other hand some degree of accommodation is found in nearly all vertebrates. Methods are varied and many, but most can be encompassed by three categories. A static lens is pulled or pushed forward and backward by appropriately placed intraocular muscles, as seen in many fish, the static lens is displaced forward or backward by muscular compression of the eyeball as in snakes and cephalopods, or the anterior curvature of the pliable lens is altered by the action of the ciliary muscle on the elastic anterior lens capsule, as seen in birds, reptiles (other than snakes) and mammals.

Such an exquisite organ as an eye, even of the simpler kind, is totally useless unless its various components are fully mature and integrated. It is difficult to believe that natural selection would be capable of accomplishing such feats of ingenuity and purpose.

In the simple eye category then, the invertebrate retina and its central nervous connections via the optic nerve follow the standard verted pattern. The few exceptions are found in the simple eyes of some spiders, scorpions and molluscs (*Pecten* and *Spondylus*) where the light sensitive cells of the retina assume a primitive inverted configuration.

It is in the Arthropoda almost exclusively that the compound eye is found, the total visual function being enhanced in many cases by the presence of simple eyes as well. Included are centipedes, millipedes, crabs, some scorpions, shrimp, some spiders and the large class of insects. The fossil trilobite apparently had a large compound eye on each side of its head with three ocelli on top. Each individual unit in a compound eye is termed an ommatidium, which is essentially a tapering, elongated tube-like structure with a surface facet or cornea, simple refracting media and a pigmented retinal cell associated with an afferent nerve at the proximal end leading to the nervous system. These individual units are packed together in a side by side parallel manner forming a compact, somewhat rounded (on the anterior surface) cone-shaped group with a surface mosaic effect. The total visual impression is a summation of the information from each unit. An example is the honey bee. There is no retina as such in a representative compound eye but a few night-flying insects have a modification whereby light from a number of individual units is focused at one place, but this in no way resembles the true retina of the higher simple eye of the invertebrates just described, or that of the vertebrates. This modification is termed the superposition eye. Having briefly described the simple and compound eyes of the invertebrates I now pass on to the vertebrates.

Vertebrate Vision

It is in the vertebrates that the eye reaches its highest state of organization and over-all visual acuity. In contrast to the invertebrates the basic design is constant and similar throughout, (Figure 2). Modifications of a minor nature are evident depending on the habits and individual requirements of the various species. The basic difference between the vertebrate retina and the retina of the invertebrates which possess one, lies in its organization. In the invertebrates the retina is verted whereas in the vertebrates it is inverted, (Figure 3). The change in configuration and position of the light sensitive cells (hereafter termed the rods and cones), from the invertebrate type to that of the vertebrates is a major one, requiring, amongst others,

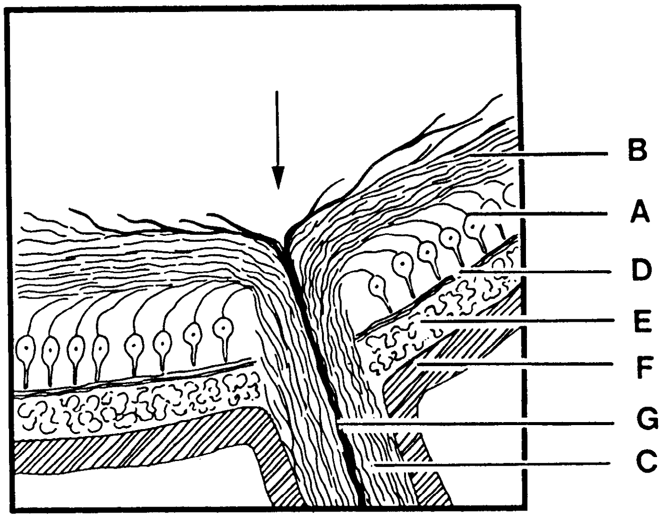

Figure 2. General Plan of the Vertebrate Eye. A: Cornea. B: Pupil. C: Iris. D: Lens. E: Vitreous. F: Sclera. G: Choroid. H: Retina (light sensitive cells, connecting cells and nerve fibre layer). I: Optic nerve. J: Fovea. K: Central retinal artery.

alteration in their blood supply, the rearrangement of the connection between the rods and cones and the optic nerve fibres, and the provision of a cone dominated fovea centralis for acute central vision. Thus the vertebrate eye is capable of sharp retinal image formation. We have seen that the eye of the invertebrate Cephalopods is also capable of image formation. In this respect therefore, organic evolution, if true, has been responsible for the appearance of an image-forming eye, not only once, which would be a remarkable enough achievement, but twice, each differing from the other in anatomical and physiological retinal characteristics. This feat would be assigning to organic evolution powers and abilities away beyond the capabilities of such a non-teleological, chance, hit and miss process.

As a consequence of the path which the afferent nerve cell fibres take in exiting from the eye through the sclera, there is unavoidably, at that place, an area where the retina is devoid of rods and cones, (Figure 3). It varies in size and shape in different species, but in comparison to the total retinal area it is quite small. As the exit site is not at the posterior pole of the eyeball, the resulting blind spot in the peripheral visual field is eccentric and barely noticeable if at all. The degree of binocular vision in many vertebrates is such that the blind spot of one eye is "covered" by the visual field of the other eye, rendering this minor defect devoid of any practical importance whatever. Of all the vertebrates, birds have the highest general ocular efficiency,[8] but in man, because his brain is the most highly developed and organized three pound moiety of matter in the universe, his total visual faculty is unsurpassed.

Evolution of Eye Not Likely

In a recent article in *Creation/Evolution* it was stated that this retinal rearrangement in the vertebrate eye is a "curse" with the nerves and blood vessels that serve the light sensitive cells passing in front of them partially obscuring the field of vision and that the octo-

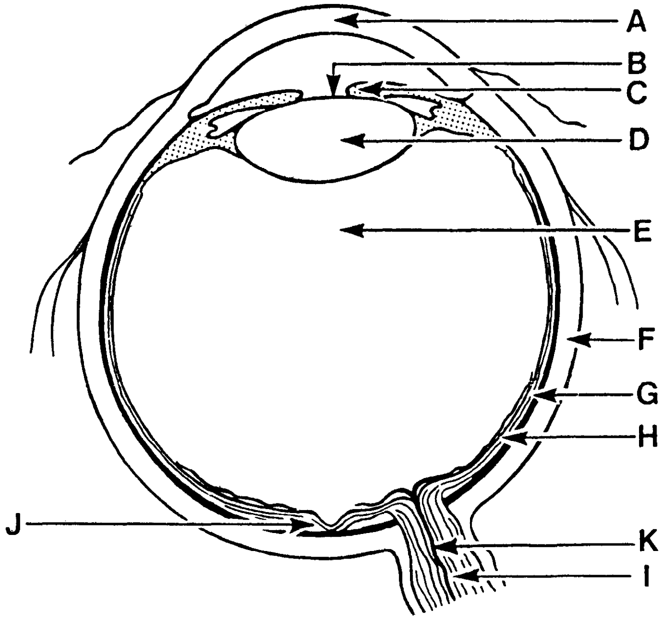

Figure 3. Vertebrate Retina (Inverted). Arrow indicates direction of light. A: Light sensitive cells. B: Nerve cell fibre layer. C: Optic nerve. D: Pigment cell layer. E: Vascular choroid. F: Sclera. G: Central retinal artery.

puses and other cephalopods have the retinas of their eyes put together "correctly" with the nerves and blood vessels tucked behind the photosensitive cells.[9, 10] That this anatomical and physiological opinion is unfounded is shown by the following facts.

In the first place the blood supply to the rods and cones in the vertebrate eye, comes not from the blood vessels passing in front of them (central retinal artery, vein and branches), but is derived totally from the choriocapillaris. This is the innermost part of the very spongy and vascular choroid which lies adjacent to and directly behind the rods and cones, and which, in no way whatever, offers any obstruction to light reaching them. Walls has this to say about the blood supply to the rods and cones in the vertebrate eye:

> The nervous tissue of the retina (other than the rods and cones, HSH) probably does not have a high rate of metabolism, but the rods and cones are very sensitive to any interference with their supplies of materials and oxygen. These come from the choroid, which aside from its light-absorbing function is wholly devoted to the nutrition of the visual cells. The turnover of substances must be very great, for the choroid is very rich in blood vessels which comprise most of its bulk in many animals.[11]

There is one known exception, the eel, *Anguilla,* in which, the choroid being absent, the whole retina, including the rods and cones, is nourished from a network of superficial vitreous vessels.[12]

As stated above by Walls, the rods and cones require a lavish blood supply, in fact greater than any other bodily tissue. That the central retinal artery and branches do not take part in this is borne out by the fact that if the artery is occluded by disease, or experimentally severed, the viability of the rods and cones is not affected.[13]

The usually small branches of the central retinal artery and vein, lying as they do in front of the rods and cones on the nerve cell fibre layer and supplying the intraocular conducting cells and fibres with oxygen and nutriments, in vertebrates do offer a very minimal hindrance to light reaching the rods and cones and thus produce micro defects in corresponding parts of the visual field. Because the course of the retinal vessels is not exactly similar in the two eyes the pattern of these micro defects is dissimilar. In an animal with some degree of binocularity, this factor, along with their micro size, renders any visual consequences or disability of absolutely no importance. Central vision is not hindered in any way, as in the foveal area of the retina there are no branches of the central retinal artery or vein.[14] It is evident therefore that the vascular supply to the vertebrate retina offers no impediment whatever to light reaching the rods and cones in the important central foveal area and is of no detriment to optimal ocular function elsewhere.

In the inverted retinal plan the light sensitive ends of the rods and cones are intimately associated with its pigment layer. Adjacent to this thin layer are reflective tissues or crystals, usually of guanin. There are different combinations and arrangements but the function of this stratum, termed the tapetum,[15] is to reflect back to the rods and cones any light that might not have been absorbed by them in its passage through the substance of the retina. Such light, if not reflected back, would be absorbed by the choroid, or other retinal tissues. Avoidance of such loss is important in those animals active at night when it is essential that all available light be utilized.

In some compound eyes in the invertebrate division, the pigment in each ommatidium, in which there are many variations on the standard plan, acts in a somewhat tapetum-like fashion. In a few invertebrates, spiders for example, which have primitive inverted retinas in their lateral and medial posterior eyes, a simple tapetum exists but it is not a feature of the invertebrates generally. The tapetum is then a structure helping the retina to utilize to the maximum all the light available to it. It is difficult to credit a purposeless, chance and random entity such as natural selection with the capability to initiate and produce such a mechanism.

In the vertebrates the nerve fibres which converge to form the optic nerve do pass in front of the rods and cones, but are not myelinated as they are in most of the rest of the body. Myelin is an opaque whitish substance which coats nerve cell processes. However, being absent in the eye, the anterior position of the unmyelinated nerve fibres offers practically no hindrance to light proceeding to the rods and cones. Congenitally, and abnormally in the human, and very rarely (0.5 percent of eyes) a small patch of these nerve fibres in the retina may be myelinated, producing an area of reduced appreciation in the visual field, of which the individual is usually completely unaware.

Hogan and Zimmerman mention with regard to the arrangement of the nerve fibres at the foveal area, the most important part of the retina: "It will thus be seen that at the fovea centralis the layers of the retina are spread aside so that the light may fall directly on the true receptive elements, namely the cones."[16]

Walls, commenting on the retina as a whole says:

> Standing on the external surface of the retina proper, and constituting its receptive layer, are the rods and cones. These elongated cells thus point away from the light which must pass through the remainder of the retina to reach them (hence the complete transparency of this tissue as contrasted with the brain which has a similar histological organization).[17]

Thus, instead of being a great disadvantage, or a "curse" or being incorrectly constructed, the inverted retina is a tremendous advance in function and design compared with the simple and less complicated verted arrangement. One problem amongst many, for evolutionists, is to explain how this abrupt major retinal transformation from the verted type in invertebrates to the inverted vertebrate model came about as nothing in paleontology offers any support.

The eye has always presented a problem to the evolutionist. In his *Origin of Species* Darwin referred to this difficulty:

> To suppose that the eye with all its inimitable contrivances for adjusting the focus to different distances, for admitting different amounts of light, and for the correction of spherical aberration, could have been formed by natural selection, seems, I freely admit, absurd in the highest degree.[18]

Much work has been done since Darwin's time but a viable evolutionary solution appears as ephemeral as ever, illustrated by the following quotes.

> It would seem therefore, that despite the considerable amount of thought expended on the question, the emergence of the vertebrate eye with its inverted retina of neural origin and its elaborate dioptric mechanism derived from the surface ectoderm, is a problem as yet unsolved. Indeed, appearing as it does fully formed in the most primitive species extant today and in the absence of transition forms with which it can be associated unless by speculative hypotheses with little factual foundation, there seems little likelihood of finding a satisfying and pragmatic solution to the puzzle presented by its evolutionary development.[19]

Froriep (1906) the great German anatomist stated that the vertebrate eye sprang into existence fully-formed, like Athena from the forehead of Zeus.[20]

J. H. Prince in his *Comparative Anatomy of the Eye* has written as follows:

> One of the essential and most important differences between vertebrate and invertebrate eyes is that in the former the receptors (light sensitive cells) point outward toward the choroid (inverted), whereas in the invertebrates they mostly point inward toward the lens (verted). But for that obstacle we should have been deluged with theories on the original evolution of the vertebrate eye from the invertebrates.[21]

Also, "There are many theories of how the reversed eye (inverted) would have arisen from the unreversed (verted) eye but on the basis of the facts none of them are viable."[22]

Conclusions

In this generalized account of the retinal structure of invertebrates and vertebrates many significant differences have been pointed out between them.

Some evolutionists have claimed that the simple verted type of retina as seen in the invertebrates, apart from the compound eye which lacks one, is properly and correctly constructed as compared with the poor and inefficient vertebrate plan. This is said to be due to the fact that, in invertebrates, there is no blind spot in the peripheral field of vision, and no blood vessels or nerve fibres passing in front of the rods and cones to minimally interfere with light reaching them. These factors have been shown to be of no real anatomical or functional disadvantage in the vertebrate eye whereas in the latter are found many superior qualities and attributes amongst which are the following: A very vascular choroid lying, not in front, but behind the rods and cones supplying them with an abundance of blood and nutriments; the possession of a fovea centralis or a macular area necessary for clear and sharp central vision; a tapetum to utilize all the available light entering the eye and a lens to ensure that incoming light focuses accurately on the rods and cones, particularly the latter as they are concentrated at the fovea. How such an advantageous and efficient arrangement could be labelled a curse or be said to be incorrectly designed is hard to comprehend.

That a mindless, purposeless, chance process such as natural selection, acting on the sequelae of recombinant DNA or random mutations, most of which are injurious or fatal, could fabricate such complexity and organization as in the vertebrate eye, where each component part must carry out its own distinctive task in an harmoniously functioning optical unit, is inconceivable. The absence of transitional forms between the invertebrate retina and that of the vertebrates poses another difficulty. Here there is a great gulf fixed which remains inviolate with no seeming likelihood of ever being bridged. The total picture speaks of intelligent creative design of an infinitely high order.

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Acknowledgment

I thank Laurie Johnston of the Biomedical Communications Department of the Children's Hospital in Vancouver, B.C., for preparing the illustrations.

ARCHAEOLOGY AND THE ANTIQUITY OF ANCIENT CIVILIZATION: A CONFLICT WITH BIBLICAL CHRONOLOGY?—PART II

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Received 30 July 1984; Revised 28 March 1985

Abstract

Two of the pillars used in support of the conventional chronology of ancient history have been the Carbon-14 dating method and astronomical dating methods. In recent years it has been recognized that there are many problems with the C-14 method and that the results of C-14 analysis are often discarded when they do not yield expected results. Velikovsky's attempt to penetrate the secret workings of the scholastic establishment shows that not all the problems of the C-14 method are technical ones. Both Velikovsky and Courville as well as other writers have exposed the weaknesses and inadequacies of the astronomical methods used to establish certain dates in Egypt's ancient history. With these two so-called "pillars" removed, the conventional chronology of ancient times loses some of its awesome sanctity and we can feel much less inhibited about considering the alternative presently being worked out by Velikovsky, Courville, and others.

The only other possible source of conflict with Biblical chronology is the duration of man's pre-historic era. But one of the main factors in assigning long intervals of time to man's pre-historic periods is evolutionary bias. If we dispose of the unfounded myth that man evolved from ape-like animals over a period of millions of years, then there is no reason why the cultural developments that occurred during the pre-historic ages could not have occurred over a relatively short interval of time.

Introduction

In Part One, I outlined the work that has been done in recent decades by a number of different scholars toward a radical reconstruction of ancient history and have shown the relevance of that work to the question of whether the antiquity of civilization in the Ancient Near East is in conflict with Biblical chronology. Several topics that are very relevant and closely related to the subject matter discussed in Part One will be discussed.

The Carbon 14 Cover-up[1]

In the late 1940's, Dr. W. F. Libby developed the Carbon-14 method for dating organic material. When Dr. Libby's work was made public, Dr. Velikovsky was immediately interested in this process as a possible means of verifying his revised dates for the New Kingdom dynasties of Egypt. In 1953, he wrote to Dr. Libby and sent him a copy of *Ages in Chaos* which had just been published the previous year. In his letter, Dr. Velikovsky briefly described his historical reconstruction and indicated the kinds of results he expected if C-14 analysis were to be performed on material from the 18th and 19th dynasties. Dr. Libby immediately returned the book claiming that he could not understand it and wrote that he knew nothing of Egyptology or archaeology.

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Ten years later Dr. Libby wrote in an article in *Science* that C-14 dates had to be separated into two groups – Egyptian and non-Egyptian – because the whole Egyptian chronology was subject to possible systematic errors and he admitted that many of the results from Egypt gave dates that were too young by as much as 500 years. But during this 10-year interval, Dr. Velikovsky had not been idle. Over a period of 11 years, from 1953 to 1964, Dr. Velikovsky and several associates of his were engaged in a letter-writing campaign to various museums and C-14 laboratories in an effort to have the C-14 method applied to material from the New Kingdom period.

One word of explanation is in order before we discuss the letter-writing campaign. Creationists are accustomed to thinking of C-14 dates as being highly inflated. Creationists generally agree that the C-14/C-12 equilibrium ratio in the atmosphere was greatly disturbed by the extraordinary conditions brought about by the Flood. The non-equilibrium conditions that existed during the period after the Flood served to greatly inflate the C-14 dates from that time with the effect gradually tapering off as a new equilibrium point was approached. While Velikovsky felt that catastrophes such as the Flood could temporarily throw off C-14 dates, he also felt that during periods when the C-14/C-12 ratio was close to an equilibrium, that the C-14 method might very well give reasonably accurate results. Velikovsky felt that the New Kingdom period in Egypt was sufficiently removed from any major catastrophe so as to yield meaningful results.