Good or bad design of the eye of vertebrates?

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The eye is the most important sense organ for primates, including us humans. Many other vertebrates rely most on other senses; dogs use their extraordinary sensitivity to odours. The eye has been important in the development of ideas about how life evolved. Charles Darwin struggled to explain how the complexity of the eye could have arisen. At the time he was working there was insufficient knowledge of a chain of intermediate stages leading to the evolved design of the eye of vertebrates. Another aspect of studies on the evolution of the eyes of vertebrates is the idea that the design is poor when compared to the optical performance of a camera made by humans. If the naturally evolved design of a vertebrate's eye is poor, then it cannot be the work of an intelligent designer in the form of a deity. Not only is the vertebrate eye compared unfavourably to cameras but also to the eye of squids and octopuses (cephalopod molluscs).

The apparent problem with the vertebrate eye is that the structure that senses light, the retina, is the wrong way round! The cells sensitive to light, the photoreceptors, face away from the incoming light. Bad design? Moreover, they are covered with layers of nerve fibres and blood vessels. The best studied eye is of course that of humans, with a vast literature written for and by eye surgeons and opticians. A human embryo starts to develop its eyes during the first few weeks of life. The retina in particular forms as a bulbous outgrowth of the brain and will remain a working part of the brain in the adult human. These bulbs each fold in on themselves, they invert by a process of differential cell growth. The inverted bulb comes to have two layers and it is the nature of the embryonic brain that it is the inner surfaces of both these layers that have the capacity to develop into a retina with a layer of photoreceptors pressed against a layer of cells that support the physiological needs of the photoreceptors.

In contrast to vertebrates, the cephalopods have their photoreceptor layer facing towards the lens of the eye, and with the nerve fibres going beneath this layer as they lead from the retina to the central brain. That works well: these invertebrate molluscs have good vision, but is it really better than that of humans? Some families of vertebrates show the highest development of vision of all animals. Think of a hawk high in the sky searching for a flicker of movement by a mouse in the grass. We primates evolved for a life in the trees, using our colour vision to search for ripening fruit and our binocular vision to swing with ease amongst the branches.

As for cameras - they are an aid to human vision. Reading glasses are a simple optical aid to the vision of a human who has become, with age, long sighted. Glasses are dead things, tools without meaning unless used by a human. A camera of powerful design mounted on a robot that lands on a comet in order to beam radio signals back to Earth to be displayed on television screens for astronomers to view is a mere dead thing without meaning or function unless information reflected from the comet's surface is brought to life and meaning in the retinas and central brains of those ecstatic astronomers. Forget about cameras and similar tools. Comparing them with living things, humans with eyes, is an error of logic, a category error.

The vertebrate eye seems to work so well because of the inverted retina, not despite it. The barrier of the nerve cell layer and retinal blood vessels to high definition vision is solved by the fovea region of the eye where light is naturally focussed. The layer of nerve fibres is as thin as possible and the inner blood vessel layer is absent here. The tiny spot of the fovea works in combination with constant tiny movements of the eyeball called saccades. These are imperceptible to us as they dart about what we concentrate our visual attention on. The immense power of the nerve cell layer of the retina to pre-process visual information helps to create a coherent impression within our central brains of the objective world. The centre of our view appears in sharp focus whilst our peripheral vision, supplied by the rest of the retina, provides the context and warns of hazards approaching.

The biochemical business of photoreception for full colour vision in bright sunlight through to the ability to grope our way by moonlight is enormously demanding of nutrients, oxygen, and disposal of waste carbon dioxide and metabolites. The retina of humans has been measured as having the highest oxygen demand of any tissue in our bodies. Even in the dark it works hard to keep the photoreceptor cells in readiness and good health. To supply the retina there is an extraordinary blood system called the choroid. This is a network of small blood vessels that is dense laterally and about three layers deep. It envelopes the outside of the eyeball and presses closely against the outermost retinal layer. The blood vessels have special gaps in their walls, permitting an exceptionally high rate of exchange with the retina. This entire adaptation for vision of dense information content is physically possible only with an inverted retina.

Using the vertebrate eye to illustrate arguments for intelligent design, or for design by natural selection, seems to be on shaky ground for both sides of the argument. However, life is full of compromises. Evolution throws up many contrary features and problems with design. The contrariness exemplified by the eye, of humans at least, is the ease with which the two layers our retinas separate from each other. There are no anatomical or cellular connections to hold the layers together, only the thin liquid between them acts as a glue, amongst other functions. The repair and prevention of retinal tears and detachments is an important part of the work of eye surgeons. For more on this website about eyes and laser surgery to repair detached retinas go to: *Contrary Life and Technical Fixes*.

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