

VESTIGIAL ORGANS ARE EVIDENCE OF EVOLUTION

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ABSTRACT: Consideration of examples of vestigial organs and of the nature of scientific statements (hypotheses) confirms the continued use of vestigial organs as evidence for the theory of evolution. It is unreasonable to infer any function for many vestigial organs, whereas others possess altered or reduced functions. The claim that vestigial organs cannot be used to support evolution is shown to be false.

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One of the more important lines of evidence used by Darwin to support his theory of evolution by means of natural selection concerned what he called "rudimentary, atrophied, or aborted organs" (Darwin, 1979, pp. 428-432). In a recent contribution, however, Scadding (1981) argues an astounding conclusion: that "'vestigial organs' provide no evidence for evolutionary theory." Lest this erroneous argument provide ammunition for the "scientific" creation school, an immediate and forceful response is essential. Scadding assumes that vestigial organs are necessarily non-functional and presents a selection of vestigial organs that are among the least convincing. I consider his arguments below, present additional examples of vestigial organs, and conclude that Scadding's arguments are without force.

DISCUSSION

That the paper by Scadding is seriously flawed is evident even on cursory reading. I shall, however, rebut the arguments case by case in order to document the strength of the argument from vestigial organs.

Scadding (p. 173) begins with the assumption that vestigial organs are necessarily non-functional and that they are, in any case, "simply a special case of homologous organs." As a vestigial organ is obviously the homolog of some non-vestigial organ in another, related organism, the second assumption contributes nothing one way or the other to the argument. The first assumption is potentially damaging, but is fallacious on two accounts: first, it is incorrect to state that to be vestigial an organ must be non-functional; and, secondly, there exist organs for which all available evidence suggests that they are truly non-functional.

In considering what vestigial organs are, the proper use of words and their proper definitions are critical. My dictionary (Funk and Wagnalls Standard Dictionary, 1966 ed.) provides the following definitions:

1. *Rudiment*: "a part, organ, or other structure that has become aborted or stunted and will always be undeveloped; a vestige."
2. *Atrophy*: "a stoppage of growth and development."
3. *Abort*: "to fail of complete development."
4. *Vestigial* (from *vestigium*, a footprint): "of, or of the nature of a vestige; surviving in small or degenerate form."

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Scadding's reply has been delayed, so we are publishing this paper now.

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Darwin used the adjectival forms of the first three terms to refer to those organs that, today, we call vestigial. Therefore, it is not essential that a vestigial organ be totally without function. Although Darwin's (1979, p. 428) treatment largely concerns those organs "bearing the stamp of inutility," he also (pp. 431-432) writes "that an organ rendered, during changed habits of life, useless or injurious for one purpose, might easily be modified and used for another purpose. Or an organ might easily be retained for one alone of its former functions." This shows that, for Darwin, vestigial organs were largely, *but not exclusively*, useless to their possessors. It would seem evident that the human coccyx, that homolog and vestige of the pre-anthropoid tail, fits precisely into the concept embodied in this quotation. Certainly it is functional (Scadding, 1981), but just as certainly it is not functioning as an external tail for balance or grasping. It is a functional, vestigial organ (*contra* Scadding, 1981).

To note (undoubtedly correctly) that the majority of Wiedersheim's (1905) list of vestigial organs in *Homo sapiens* do seem to be contributing, at some stage or another, to the adaptive plan of the individual does not, therefore, forbid either their status as vestigial, or reject their great use in documenting evolution. To return to the example of the human coccyx: this organ certainly contributes positively to the individual organism. Nevertheless, it is *also* rudimentary in comparison to its homolog in other mammals and is most reasonably explained on the theory of descent with modification. Regardless of how definitions are altered to suit particular arguments, the fact remains that the coccyx, ear muscles, and semilunar fold of the eye provide powerful suggestive evidence for the evolution of man from "lower" primates. One may choose to deny that these structures are really vestigial organs by a definitional change, but a "rose by any other name. . ."

In addition, there are organs for which all available evidence suggests that the only reasonable hypothesis is that they lack functions. To argue that someone, somewhere, at some time may suggest an imaginative function for such organs is to very seriously misunderstand the structure of science (see also below). Science is concerned with possibilities and probabilities for which evidence from the material world allows continued testing. Science does not deal in absolute proof, but with statements that seem reasonable given the available data (e.g., Popper, 1959).

Even a cursory glance at the morphological and evolutionary literature shows a plethora of vestigial and rudimentary structures overlooked by Scadding. Some of these are undoubtedly functioning in reduced and/or altered manner; for others it is not reasonable to hypothesize any sort of function. A summary of examples follows:

A. Mammals:

1. Teeth in embryos of whale-bone whales (de Beer, 1958).
2. Milk teeth, with replacement buds, in young platypus (Anderson and Jones, 1967).
3. Upper incisors, which never cut through the gums, in embryonic calves (Darwin *in* Stauffer, 1975).
4. Egg tooth and caruncle in some marsupial embryos (Hill and de Beer, 1950).
5. Variable expression of canines in modern horses -- *usually* present in males and *usually* lacking in females (Simpson, 1951).
6. Vestigial incisors in rats, mice, and rabbits (Mose-Salentjin, 1978).
7. Vestigial pelvic bones in whales (Grant, 1963).
8. Rudiment of Jacobson's organ in human embryos (de Beer, 1958).
9. Body hair in embryonic whales and humans (de Beer, 1958).

10. Side toes reduced to vestigial splints in adult horses. This reduction to vestigial condition is traced through stratigraphic sequences, as well as ontogenetically, and some modern horses retain side toes as adults (Simpson, 1951; Gould, 1980).
11. Variable development of the usually non-functional scalp muscles (either frontal or occipital bellies may be absent) and extrinsic muscles of the ear (marked variability in size and rarely lacking; Gray, 1959).

B. Birds.

1. Third toe in young ostrich, but lost in adult (de Beer, 1958).
2. Vestigial wing in Cretaceous *Hesperornis*, represented by only a very thin humerus (Feduccia, 1980).
3. In the New Zealand Kiwi, "wings are truly vestigial, and the 2 inch structures that bear claws at the tips are completely hidden by their coarse plumage" (Feduccia, 1980, p. 128).
4. "Very rudimentary" wings in emus and cassowaries (Feduccia, 1980).
5. Frigate birds, which do not land on water, possess toes united by a very reduced web (Darwin in Stauffer, 1975).

C. Amphibians and Reptiles.

1. Vestigial eye muscles in at least some caecilians (personal observation).
2. Vestigial eyes in all caecilians, as well as in cave-dwelling salamanders (often light sensitive, but of variable development among different taxa).
3. Variable presence of a nasal bone in some individuals of the salamander *Rhyacotriton olympicus* (Wake, 1980).
4. Vestigial transverse processes on the coccyx (urostyle) of leptodactylid and bufonid anurans (Trueb, 1973).
5. Rudiments of intercostal muscles in some chelonian embryos (de Beer, 1958).
6. Hindlimb vestiges in embryonic *Anguis*, which are lost in the adult. In snakes, some retain remnants of the pelvic girdle in the adult, others do not; whereas caecilians show no development of limbs or girdles at any stage.

D. Invertebrates.

1. Vestigial abdominal limbs in some myriapods (de Beer, 1958).
2. Wing vestiges in some dimorphic carabid beetles (Darlington, 1980).
3. Primitive insects possess supernumerary limb buds in larval stages, whereas advanced insects do not.

This list could be easily expanded, but serves to show the abundance of examples available. When considering such examples, it is important to keep in mind Darwin's criteria for recognition of vestigial organs: that is, they tend to be of variable development and are sometimes absent from certain individuals. For example, the variable expression and occasional absence of the scalp and ear muscles in humans; the variable development of eyes in cave-dwelling salamanders and burrowing caecilians; the common (but not exclusive) absence of the nasal bone in *Rhyacotriton*; the presence in some, but not all, frogs of transverse processes on the coccyx; and the variable development and expression of hindlimbs and limb girdles in lizards, snakes, and caecilians, make it very difficult to fall back on an explanation of embryological organizers or altered function for at least these structures. Scadding may, of course, be correct and some ingenious researcher may propose an elegant scenario for a functional interpretation of one or another of the listed features. However, at present, the most reasonable explanation is that they actually lack functions and are to be considered truly vestigial by Scadding's definition. Even if functions were to be ascribed to any of them, they would still provide powerful evidence for the theory of evolution.

To complete this discussion, I consider the nature of scientific hypotheses and of the philosophy of science. Scadding (p. 175) claims that vestigial organs have been used both theologically (to argue against special creation) and scientifically (to argue for evolutionary theory). If one reads Darwin's argument as published in *On the origin of species*, it is clear that this dichotomy is wholly artificial: Evidence for evolution is automatically evidence against special creation.

Darwin relied heavily on vestigial organs to counter the the theological "argument from design." Briefly stated, this latter proposal asserted that the occurrence of perfectly designed organisms necessitated the existence of a designer, obviously strong support for the creation myth of Genesis. However, Darwin was able to show that, in fact, organisms are often something less than perfectly created machines. The occurrence of variable and rudimentary organs indicated that plants and animals were produced by a tinker modifying, altering, and slowly removing pre-existing structures. It seems more reasonable to conclude that this tinker is natural selection rather than a god. Given the nature of the two explanations, any evidence in favor of one is necessarily against the other.

If theology presumes to speak of the natural, material world, its statements become open to scientific examination and potential falsification. Theologians stated that the universe was geocentric, and found this claim falsified; they stated that each "kind" was specially created a few thousand years ago, and found this claim resoundingly falsified in 1859.

Finally, Scadding turns to consideration of the scientific nature of statements about vestigial organs. Once again confusion is evident: He first notes the practical problem of identifying vestigial organs (considered to be necessarily non-functional), and provides evidence that his chosen examples probably have some remaining function. This is, however, to fall into a common fallacy -- that of confusing real things with the difficulties encountered in identifying them. For example, it is well known that species are often very difficult to identify with certainty in nature. However, this does not invalidate the biological species concept (see Simpson, 1961). If Scadding's objection were to be applied broadly, and science limited to those things about which we are absolutely certain, very little would be left to the domain of science. Of course, Scadding's interpretation is incorrect (e.g., Popper, 1959) and this criterion of a scientific statement is meaningless -- only theology claims to deal in absolute truth.

Scadding's second point about the scientific validity of statements concerning vestigial organs is also confused. He argues (incorrectly, see above) that the argument from vestigial organs necessarily assumes that the organ has no function. He states (pp. 175-176) that "one cannot prove that something does not exist (in this case a certain function), since of course if it does not exist one cannot observe it, and therefore one can say nothing about it scientifically." It is evident that this is rather naive sophistry. Popper (1959, 1968), among others, has gone into the nature of scientific statements at great length and very effectively demolishes arguments such as that proposed by Scadding. The statement that such and such an organ has

no function (i.e., is vestigial in Scadding's narrowed definition) is simply an hypothesis based on the interpretation of available data, and open to potential falsification by demonstration that the organ does have some sort of role in aiding individual survival. As such, these statements are fully scientific under Popper's criterion of potential falsifiability. By way of demonstration, the classic statement (hypothesis) that "all crows are black" entails the complete absence of white crows from the natural world -- it is a statement about the non-existence of something (in this case a white crow rather than a function). Statements of this sort are completely valid scientifically, as are hypotheses of the non-existence of functions.

I conclude, with Darwin, that rudimentary, atrophied, and aborted organs provide one of the more powerful evidences for the theory of evolution. They are readily explainable under the idea of descent with modification, indeed are an expectation of it, but very effectively indicate that the theory of special creation (and the argument from "design"), whatever its theological attributes, has been convincingly falsified scientifically.

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