

DO 'VESTIGIAL ORGANS' PROVIDE EVIDENCE FOR EVOLUTION?

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ABSTRACT: The existence of functionless 'vestigial organs' was presented by Darwin, and is often cited by current biology textbooks, as part of the evidence for evolution. This paper examines the origin and nature of this argument tracing it to the works of Darwin, Haeckel, and particularly Wiedersheim. An analysis of the difficulties in unambiguously identifying functionless structures and an analysis of the nature of the argument, leads to the conclusion that 'vestigial organs' provide no evidence for evolutionary theory.

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In almost all biology textbooks that discuss the "evidence for evolution", vestigial organs are cited as one piece of evidence that supports evolutionary theory (Johnson et al. 1972; Kimball 1974; Moody 1970; Stephens and North 1974; Taylor and Weber 1968; Vilee and Dethier 1971). The argument is usually presented in the following manner. Virtually all animals possess organs or structures that have no function. These are homologous to organs or structures that are functional in other related animals. Consequently, these vestigial organs are interpreted as organs that, having lost their usefulness, are in a process of evolutionary decay and can be expected to be eliminated during the course of future evolution. Thus, they provide evidence for the theory of evolution, i.e. that the animal possessing the vestigial structure is a descendant of an animal that possessed the homologous structure in a functional condition. Examples of vestigial structures are given, usually for humans but sometimes with examples from other animals or plants. Vestigial organs identified in the human typically include the vermiform appendix, coccyx, ear muscles, semilunar fold of the eye, and occasionally others. Some textbooks claim that there are over one hundred vestigial structures in the human body, but notably do not list more than five or six (Stephens and North 1974; Taylor and Weber 1968; Vilee and Dethier 1971). It is the purpose of this paper to review and evaluate this argument.

Vestigial organs represent simply a special case of homologous organs, i.e. structures similar in fundamental structure, position, and embryonic development, but not necessarily in function. That all vertebrates, for example, are built along a common basic structural plan is obvious to any student of anatomy. While homologies between animal species suggest a common origin, the argument given above asserts that vestigial organs provide special additional evidence for evolution. Our knowledge of anatomy, necessary to identify homologies, is based on straightforward observation of adult or embryonic structure. However, when one begins to investigate the function of these structures necessary to identify vestigiality, the situation is not so clear. In many cases the functions of minor structures are not well understood. Identification of function is often based on experimental procedures, the results of which require some interpretation. Hence, our knowledge of function can never be as secure as our knowledge of anatomy.

The presentation of vestigial or rudimentary structures as evidence for the theory of evolution goes back to Darwin. He discussed "Rudimentary, Atrophied, and Aborted Organs" in the following terms. "Organs or parts in this strange condition, tearing the plain stamp of inutility, are extremely common, or even general, throughout nature. It would be impossible to name one of the higher animals in which some Part or other is not in a rudimentary condition" (Darwin 1872, p. 619). In "The Descent of Man" Darwin discusses rudimentary structures in the human body and lists: the muscles by which the skin can be moved, the muscles of the ear, the semilunar fold of the eye, the sense of smell, body hair, the posterior molars (wisdom teeth), the

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vermiform appendix, the coccyx, and reproductive structures of the opposite sex (Darwin 1874, p. 11-24). He described these as structures which are of no use to man but were of great use to his ancestors and hence interprets these observations as supporting common descent. "In order to understand the existence of rudimentary organs, we have only to suppose that a former progenitor possessed the parts in question in a perfect state, and that under changed habits of life they became greatly reduced, either from simple disuse, or through the natural selection of those individuals which were least encumbered with a superfluous part, aided by the other means previously indicated" (Darwin 1874, p. 24). Darwin never makes entirely clear why this particular class of homologous structures should provide such important support to his theory of descent with modification.

Haeckel makes clear why this line of argument was of such importance to early evolutionary biologists. Nineteenth century creationists had held to the position that the creation of man and the animals by God was 'perfect' and hence the observations of organs which had no apparent function proved something of an embarrassment to them. Various interpretations were placed on organs whose functions were unknown including the idea that the creator had placed them there for the purposes of symmetry, or as mere decorations. It seemed difficult to explain functionless structures on the basis of special creation without imputing some lack of skill in design to the creator. Obviously, the theory of evolution could provide a much more satisfactory explanation than that, consequently rudimentary organs were much played up in arguments of evolutionists. Functionless organs were clearly a distinct embarrassment to anyone who wished to talk of the purpose of nature. Haeckel refers to these rudimentary organs as a "dysteleological proof of evolution" (Haeckel 1899, p. 11-20; 1903, p. 436-440). It should be noted however, that presented in this way, the vestigial organ argument is essentially a theological rather than a scientific argument, since it is based on the supposed nature of the Creator.

The identification of vestigial organs especially in humans reached a zenith in the work of the German anatomist, Wiedersheim. It is apparent that the discussion of vestigial organs in many biology textbooks owes more to Wiedersheim than to Darwin. In "The Structure of Man", Wiedersheim (1895) attempts to analyse human anatomy in evolutionary terms. Much of his work is based on determining which human anatomical characteristics are retrogressive and which are progressive. Hence, the identification of vestigial organs becomes for Wiedersheim a matter of extreme importance. He provides a list of eighty-six vestigial organs (Wiedersheim 1895, p. 200-202), as well as many others that he considers to be retrogressive. His list of vestigial organs can be divided into four groups. The first group includes those clearly incorrectly identified as vestigial organs and which in fact have very important functions, e.g. the pineal gland, pituitary body, lachrymal glands. A second group of Wiedersheim's vestigial organs (including the majority) are probably best described as structures of limited or minor function. This would include many minor muscles and minor bone modifications as well as structures such as the phalanges of the 3rd, 4th, and 5th toes, wisdom teeth, certain valves of the veins, the area scroti, etc. However, natural selection would be expected to operate even if a structure has only a minor adaptive advantage. A structure need not be of major importance for natural selection to act on it. Fisher (1932) has shown that only when the selection coefficient is less than the reciprocal of the population size would natural selection cease to be effective. Prout (1964) goes further and states that evolutionary theory in general would be in trouble if the efficacy of very mild selection were in doubt.

A third category of Wiedersheim's vestigial organs would include those structures that only function during the embryonic period, e.g. notochord and parts of the embryonic circulation system such as the posterior cardinal veins and ducts of Cuvier. Even structures that function only during a part of the organism's life, may still provide an adaptive advantage and should not be considered functionless. A fourth category of vestigial organs would be those that are vestiges of the reproductive structures of the opposite sex, e.g. nipples in men, vestiges (in the female) of the Wolffian duct, and (in the male) of the Mullerian ducts. These structures, however, clearly

reflect the embryonic development of a sexually dimorphic organism which begins its development in a sexually indifferent condition with structures characteristic of both sexes. They certainly do not reflect phylogenetic development. No one supposes males evolved from females or vice versa. On the basis of this analysis, I would suggest that Wiedersheim was largely in error in compiling his long list of vestigial organs. Most of them do have at least a minor function at some point in life.

Current textbook writers then, in presenting the argument that vestigial organs provide evidence of evolution, may claim that there are over one hundred in the human body, erroneously following Wiedersheim, but only give a few examples. The usual examples are the vermiform appendix, the coccyx, ear muscles, and the semilunar fold of the eye (all of which are also described as vestigial organs by Darwin). "To most biologists, therefore, the presence of small organs that seem to have no function in themselves but correspond to functional organs possessed by other animals indicates inheritance from common ancestry" (Moody 1970, p. 44). Most authors regard this as an entirely scientific argument. Others clearly extend it into the philosophical or religious realm as well, by using it as a theological argument against special creation (e.g. Moody 1970, p. 42-43). I suspect that this argument gained widespread use not because it proves anything about evolution, but because it was thought to have particular force against some varieties of creationism.

I would suggest that the entire argument that vestigial organs provide evidence for evolution is invalid on two grounds, one practical, the other more theoretical. The practical problem is that of unambiguously identifying vestigial organs, i.e. those that have no function. The analysis of Wiedersheim's list of vestigial organs points out the difficulties. As our knowledge has increased the list of vestigial structures has decreased. Wiedersheim could list about one hundred in humans; recent authors usually list four or five. Even the current short list of vestigial structures in humans is questionable. Anatomically, the appendix shows evidence of a lymphoid function since the submucosa is much thickened and almost entirely occupied by lymphatic nodules and lymphocytes (Gray and Goss 1973, p. 1242). There is experimental evidence as well, that the vermiform appendix is a lymphoid organ which acts as a reservoir of antibody producing cells (Anonymous 1960).

The coccyx serves as a point of insertion for several muscles and ligaments including the gluteus maximus (Gray and Goss 1973, p. 118). The semilunar fold of the eye is simply that portion of the conjunctiva at the medial corner of the eye and as such aids in the cleansing and lubrication of the eye ball (Gray and Goss 1972, p. 1065). The absence of a nictitating membrane in humans is of no significance to a discussion of the function of the semilunar fold. Similarly, for other 'vestigial organs' there is reasonable grounds for supposing that they are functional albeit in a minor way. Yablokov (1974, Chap. 6) has discussed at length the great difficulty of identifying vestigial organs, by analysing in detail the alleged vestigial organs of marine mammals. I would conclude that in practice it is difficult if not impossible to unambiguously identify organs totally lacking in function.

The other major objection to citing vestigial organs as evidence of evolution is a more theoretical one based on the nature of the argument. The 'vestigial organ' argument uses as a premise the assertion that the organ in question has no function. There is no way however, in which this negative assertion can be arrived at scientifically. That is, one can not 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. The best we can do is to state that despite diligent effort, no function was discovered for a given organ. However it may be that some future investigator will discover the function. Consequently, the vestigial organ argument has as a premise, either a statement of ignorance (I couldn't identify the function), or a scientifically invalid claim (it does not have a function). Such an argument, from ignorance, or from negative results, is not valid scientifically, and has no place in observational or experimental science.

Since it is not possible to unambiguously identify useless structures, and since the structure of the argument used is not scientifically valid, I conclude that 'vestigial organs' provide no special evidence for the theory of evolution.

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