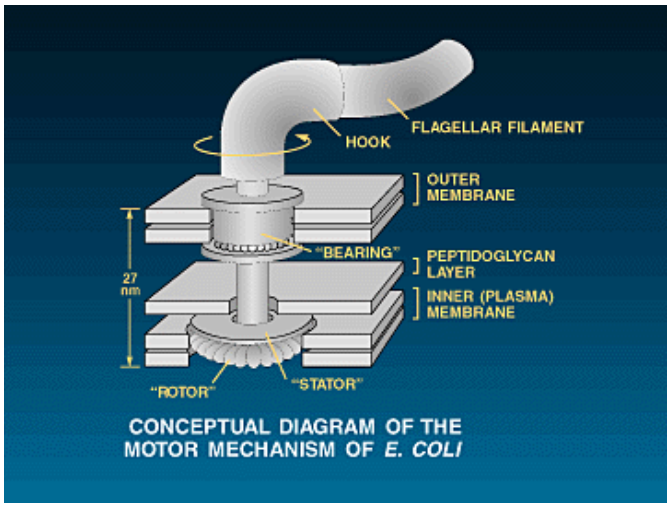
THE BACTERIAL FLAGELLUM



The bacterial flagellum as part of the motor mechanism of E.Coli bacteria is an example of what Michael Behe describes in his book, Darwin's Black Box, as an irreducibly complex system.

Darwinism, or popularly known as evolution theory or naturalism, relies on gradual evolvement of intricate organs or limbs to eventually become a particular specie.

Behe summarizes the structure of the bacterial flagellum in these terms:

Some bacteria boast a marvellous swimming device, the flagellum, which has no counterpart in more complex cells. In 1973 it was discovered that some bacteria swim **by rotating their flagella (tail). So the bacterial flagellum acts as a rotary propellor.**

The structure of a flagellum is a long, hairlike filament embedded in the cell membrane. The flagellum is the paddle surface that contacts the liquid during swimming. At the entrance of the flagellum into the cell, there is a bulge in the thickness of the cell. **It is here that the filament attaches to the rotor drive**. Experiments have demonstrated that the motor driving the flagellum is located at the base of the flagellum, where electron microscopy shows several ring structures occur. The rotary nature of the flagellum has clear, unavoidable consequences ... (pp. 70-72)

The consequences Behe refers to are inferred by the nature of its irreducibly complex components, **the discovery of which undermines a Darwinian explanation of origins.**

In his book, Darwin's Black Box, Behe explains that such irreducibly complex systems **could not have arisen by a gradual step-by-step Darwinian process,** because the bacterial flagellum is necessarily composed of at least three parts -- a paddle, a rotor, and a motor -- **it is irreducibly complex**. **Gradual evolution of the flagellum, therefore, faces mammoth hurdles**.

As biochemists have begun to examine apparently simple structures like flagella, they have discovered staggering **complexity, with dozens or even hundreds of precisely tailored parts**. It is very likely that many of the parts we have not considered here are required for any flagellum to function in a cell. **As the number of required parts increases, the difficulty of gradually putting the system together skyrockets, and the likelihood of indirect scenarios plummets**. Darwin looks more and more improbable. Darwinian theory has given no explanation for the flagellum. The overwhelming complexity of such swimming systems push us to think it may never give an explanation. (p. 73)

Behe concludes that such irreducibly complex systems **were ultimately the result of intelligent design**.

Objections to Intelligent Design

Most scientists will argue that "intelligent design" is not a purely naturalistic or materialistic explanation of the origin of biological information and hence is not a valid scientific explanation. Often hidden within this argument is the philosophical or theological assumption that God (or any other intelligent agent) did not play any active, direct, or discernable role in the creation of any biological system. **This assumption requires that all genetic information must have arisen on a totally random and/or gradual step-by-step basis.** It follows that nature must be continuous and natural history must be represented by a tree of life.

Ironically, scientists are **more constrained under a paradigm of naturalism (evolution)** than they are under a paradigm of **intelligent design**. Intelligent design of the universe may have included the creation of natural laws and initial conditions sufficient to allow the evolution of a single tree of life on earth. Intelligent design may also have included punctuations throughout natural history, direct acts of creation or the infusion of new genetic information, which resulted in natural discontinuities.

Does Natural Selection Inhibit Major Evolutionary Change?
(from On The Origin of Stasis (lack of change) by Means of Natural Selection
There are numerous examples of organisms with systems of highly specialized, interdependent components, all of which must be integrated before they are functional and offer any selective advantage. Nature abounds in such systems of "irreducible complexity." Although there may be some examples where certain components take on some pre-adaptive function, these cases may be considered as exceptions to a more general rule. As a rule, any subset of the components would prove to be a burden to an organism and thus be eliminated by natural selection. Take for example the sensory and motor mechanism of the common bacterium, Escherichia coli, a relatively simple unicellular prokaryotic organism.

The sensory and motor mechanism consists of a number of receptors, which initially

detect the concentrations of a variety of chemicals. Secondary components extract information from these sensors, which, in turn, is used as input to a gradient sensing mechanism. **The output of this mechanism is used to drive a set of constant torque proton-powered reversible rotary motors which transfer their energy through a microscopic drive train and propel helical flagella**. This highly integrated system allows the bacterium to **migrate at the rate of approximately ten body lengths per second**. Dr. Robert Macnab of Yale University concluded a major 50 page review of this mechanism with these remarks:

As a final comment, one can only marvel at the intricacy in a simple bacterium, of the total motor and sensory system which has been the subject of this review and remark that our concept of evolution by selective advantage must surely be an oversimplification. What advantage could derive, for example, from a "pre-flagellum" (meaning a subset of its components), and yet what is the probability of "simultaneous" development of the organelle at a level where it becomes advantageous?

Macnab, R. (1978), "Bacterial Mobility and Chemotaxis: The Molecular Biology of a Behavioral System," CRC Critical Reviews in Biochemistry, vol. 5, issue 4, Dec., pp. 291-341

Further Reading

A good general introduction to flagella can be found in Voet, D. and Voet, J. G. (1995) Biochemistry, 2nd edition, John Wiley and Sons, New York, pp. 1259-1260.

Greater detail about the flagellar motor can be found in the following:
Schuster, S. C. and Khan, S. (1994) "The Bacterial Flagellar Motor," Annual Review of Biophysics and Biomolecular Structure, 23, 509-539; Caplan, S. R. and Kara-Ivanov, M. (1993) "The Bacterial Flagellar Motor," International Review of Cytology, 147, 97-164.