Measuring evolution: New approach proposed

Scientists may be barking up the wrong evolutionary tree with their current approach to studying the changes in animals during evolution. The genetic changes that lead to new body characteristics—feathers instead of hair, brown spots instead of black, long neck instead of short—may not begin with changes within genes, as is now generally thought. These morphological changes may instead stem from the rearrangement of genes, or changes in the control of existing genes. This difference in emphasis, explained in a newly presented theory, could clarify some puzzling discrepancies in current evolutionary and genetic data.

Biochemists Mary-Claire King of the Hooper Foundation in San Francisco and A. C. Wilson of the University of California at Berkeley explain in the April 11 SCIENCE that there are two ways of measuring the genetic similarities of different animals. One can look at differences on the biochemical level —differences in the types and structures of proteins and enzymes found in each animal—by using electrophoresis, immunological analysis and gene sequencing techniques. Or, one can look at differences on the organismal level, such as differences in anatomy, physiology, behavior and habitat and get an idea of genetic distance.

The two animals most thoroughly studied by both biochemical and organismal methods are chimps and humans. King and Wilson compared data on the microscopic and macroscopic differences between the two species, and found them to be quite similar biochemically. By comparing data on 44 proteins and enzymes common to both animals they found that the average human polypeptide is more than 99 percent identical to polypeptides in chimps. Summarizing the biochemical comparisons, they state ". . . the genetic distance between humans and chimpanzees is well within the range found for sibling species of other organisms." (Sibling species are often so similar in appearance that it takes careful biochemical analysis to tell them apart.)

Yet, clearly, chimps and humans are quite different creatures in anatomy, physiology, behavior and habitat. What could account for such biochemical similarity and yet such organismal dissimilarity? King and Wilson's theory may answer this riddle.

The evolution of external characteristics is separate and may proceed by processes different from the evolution of proteins and enzymes, they state. Major anatomical differences may reflect changes in the arrangement of genes on the chromosomes or changes in the sequences that control the expression of existing genes. Subtle evolutionary variations, such as new amino acid sequences in a polypeptide, might be results of changes within genes.

Little is understood about the control of genes—how they are turned on and off and which sequences are responsible for regulation. But a mutation in this regulatory machinery could lead to more dramatic changes than would a mutation in a nonregulatory sequence, Wilson says, and possibly lead to the expression of quite different characteristics. There is some preliminary evidence to this effect in the case of chimps and humans. Although they are biochemically similar and have similar chromosome numbers (humans 46, chimps 48), chromosome banding studies reveal great dissimilarity, implying that gene orders on the chromosomes are quite different.

The King and Wilson theory may initiate a new approach to measuring genetic distance and tracing the divergence of species. "In my opinion," Wilson says, "we shouldn't be devoting all of our attention to examining protein differences. Geneticists and evolutionary biologists have been unconsciously choosing the belief for years that changes within genes were causing the phenotypic changes seen at the organism level rather than the changes in patterns of gene regulation and arrangement. We are going to have to think about doing some new types of experiments now to see if the arrangement and control of genes are the more important influences." □

Successful transplant of cat muscle

A technique used to try to prove a misguided genetic theory in Lysenko-era Russia has helped scientists transplant muscles in cats.

The technique is called "pre-denervation," and involves severing the nerves in muscle tissue three weeks before it is transplanted to another location in an animal's body. By pre-denervating cat leg muscles, University of Michigan biologists have successfully transplanted them from right legs to left and vice versa, and achieved 50 percent restoration of muscle mass and 30 percent restoration of contracting ability. John A. Faulkner, Leo C. Maxwell, Shahzad A. Mufti and Alene W. Turowski of the departments of physiology and anatomy presented their work at the recent meeting of the Federation of American Societies for Experimental Biology.

A University of Michigan colleague, morphologist Bruce M. Carlson, brought the pre-denervation technique back from the Soviet Union after seeing it used there, and explained the Lysenko connection to SCIENCE NEWS. In the Soviet Union in the 1940's, morphologist Alexander N. Studitsky searched for evidence to confirm a Lysenko-style theory, the "new cell theory." This theory held that new cells arise in living organisms from an unidentified noncellular living substance. Studitsky "proved" this theory by removing the large leg muscles from rats (and later, chickens), chopping them up, replacing them, and observing the regeneration of new cells.

From these experiments, Studitsky formulated the concept of a "plastic condition." This held, Carlson says, that a special state of flux brought on by trauma must exist before regeneration occurs. Studitsky found that the mincing and replacement of muscle tissue and pre-denervation were two pretreatments that could produce the "plastic condition" in muscle, and subsequent regeneration of muscle tissue.

Although the new cell theory has since been discredited, pre-denervation does, for some reason, seem to increase the regeneration of muscle tissue. The technique was revived in the early 1970's, and Carlson brought it to the United States for use in basic muscle transplantation studies. About the same time, a British plastic surgeon began using it clinically.

The Michigan group, physiologist Maxwell explains, is right now most interested in an understanding of the basic processes involved in muscle regeneration. Muscles had been transplanted from one location to another in rats, but the team's successfully transplanted cat muscles are eight to ten times as big as the transplanted rat muscles. The team hopes this successful cat muscle transplantation will allow them to measure intermuscular blood flow (rat muscles are too small for this), and thus to get a better understanding of metabolic activity during degeneration and regeneration in mammalian muscle tissue. □