EPISODIC EVOLUTIONARY CHANGE IN LOCAL POPULATIONS

H. L. Carson
Department of Genetics and Molecular Biology
John A. Burns School of Medicine
University of Hawaii
Honolulu, Hawaii 96822 USA

THEORETICAL BACKGROUND

Active evolutionary change occurs in a sexual deme. This local population is the site where natural selection processes genetic variability. Within the constraints of chance in populations of finite size, selection determines what the genetic composition of the descendant population will be. What kind of deme structure best serves the process of novel evolutionary change? This question continues to be a major area of research in evolutionary genetics. Two hypotheses have recently been discussed. Barton and Charlesworth (1984) and Barton (1989) hold a traditional gradualist view, namely that such change proceeds most actively in a large undivided population that is widely open to gene flow. The incorporation of changes in the gene pool is viewed as a continuous process, with only small increments of change imposed by natural selection in each successive generation.

On the other hand, Carson and Templeton (1984) support a theory holding that novel character change occurs episodically in populations of small size. When deme size is constricted by a population bottleneck, change is thought to occur most actively in the generations that immediately follow. Although rare alleles may be lost from a bottlenecked population by random drift, much genetic variability nevertheless can pass into the daughter population (Nei et al. 1975). In the parental generation, genetic variability for quantitative traits is likely to be tied up in balanced coadaptive polymorphisms and is thus not freely available to selection.
Following the founder event, these equilibrated polymorphisms may be destabilized. There is evidence that this process can release novel genetic recombination products or other genetic variance to the action of natural selection (see Carson 1990a for a recent review).

A population bottleneck thus merely acts as a trigger that increases the array of genetic variability available to natural selection. Although the participation of major genes or macromutations is not excluded, new single mutants of this sort are not, in my view, required by the theory (Carson 1989, 1990b). Novel change can result from polygenic restructuring and novel selection of quantitative characters (Lande 1981). Over a series of generations immediately following a bottleneck, directional evolution would be expected to be rapid. Later, this active process slows down, as a new equilibrium is reached within the gene pool. Character change is thought to be accomplished through the establishment by selection of new systems of interacting genes rather than substitution of old alleles by new ones. Accordingly, this theory is less dependent than its alternate on the idea that improbable point mutations having specific phenotypic effects must arise and be individually fixed by selection before character change is realized.

Both the gradual and episodic views are strictly neodarwinian and microevolutionary. Both hold that the local population or deme is the site of active evolutionary change and that natural selection is of all-pervading importance. Both theories invoke natural selection to maintain the genetic status quo when the population is running along at equilibrium. Thus, the main point of contention between the opposing theories centers on the demography of the population that is able to actively incorporate novel genetic change. It is the purpose of this paper to discuss those population structures that appear to be conducive to episodic genetic change.