The Dynamics of Social Learning

Cultural Transmission and Evolution. A Quantitative Approach. L. L. CAVALLI-SFORZA and M. W. FELDMAN. Princeton University Press, Princeton, N.J., 1981. xiv, 388 pp. Cloth, $25; paper, $10.50. Monographs in Population Biology, 16.

In 1971 L. L. Cavalli-Sforza noted the possibility that a detailed analogy could be drawn between biological evolution through DNA and cultural evolution that bypasses DNA. Many others had noted the analogy, but population geneticists had neglected the transmission and evolution of learned human behavior in favor of genetic problems for which the underlying (Mendelian) mechanisms were known. The known laws governing social learning have been neither as precise nor as parsimonious as Mendel's laws, so there seemed to be little hope for a rigorous theory of cultural evolution. Cavalli-Sforza and his colleague Feldman, however, demonstrated that cultural transmission could be formally quantified by mathematically straightforward modification of classical population genetics. This quantitative approach catalyzed work by others so that the study of developmentally complex traits has been revolutionized in the past decade. In this book Cavalli-Sforza and Feldman summarize and elaborate their own work, which has been previously published in scattered sources. Bringing together these individual elements facilitates generalization about the overall pattern of their results.

They cautiously make the minimal assumptions about cultural change that are needed to answer the key questions of interest to mathematically oriented population biologists: What are the dynamics of changes in the relative frequencies of the alternative forms of individual learned traits within a population? What ensures convergence of a trait to a stable equilibrium?

Both similarities and differences between cultural and biological evolution are described in detail. The dynamics of cultural change is viewed as the balance among several evolutionary forces: (i) cultural mutation, which includes both purposive innovations and random errors of imitation whereas genetic mutation is strictly copy error; (ii) cultural transmission, which involves social learning and so may proceed from parents and nonparents whereas genes are inherited from parents only; (iii) cultural migration, which includes both the physical movement of people with their ideas and other methods of information flow whereas biological migration involves only the physical movement of people with their genes; (iv) cultural drift due to sampling fluctuation in local finite populations, which is common to cultural and biological evolution; (v) cultural selection, which is unique to cultural change because it involves decision-making by individuals; and (vi) natural selection or consequences of Darwinian fitness, which are common to the two types of evolution. The use of the term "cultural selection" is appropriate because it refers both to choices by the individual human beings ("first-order organisms") and to the fitness of the products of their behavior and beliefs ("second-order organisms" like stone tools or violins).

This analogy between cultural and biological evolution has forced a fundamental change from the traditional perspective of cultural anthropology and sociology, in which individual traits are viewed in relation to one another rather than individually in relation to the human organism (see for example L. A. White, "The concept of culture," *Am. Anthropol.* **61**, 227 [1959]). Here cultural evolution is considered not in terms of the interaction of individual elements but only as the sum of the individual traits. By failing to consider the interaction and integration of the individual elements of a culture, Cavalli-Sforza and Feldman never reach the phase of sociocultural change that is of most interest to sociology and cultural anthropology.

Traditionally sociocultural change is characterized by three phases: innovation, decision-making leading to selection or rejection of the innovation, and integration of the innovation with other elements of the culture. In contrast the authors' treatment of cultural change is limited to the first two steps. This simplification is inspired by analogy from two-stage models of the spread of infections (susceptible → infectious → resistant or dead) to the spread of innovations (naïve → aware → adopted). These two stages, cultural signaling or perceptual awareness and cultural selection or decision-making, are similar to the primary and secondary epigenetic rules of the model developed by Lumsden and Wilson (see review 2 August, p. 749). However, Cavalli-Sforza and Feldman assume here that there are no individual genetic or cultural differences in learning. Their sole goal here is to characterize the dynamic properties of pure cultural transmission without gene-environment interaction or individual differences in predisposition.

Since social learning is not limited to inheritance from parent to child, the authors consider 11 possible modes of transmission that vary according to the number of transmitters per receiver and other social and biological relations between members of the social network. These patterns of transmission are classified into three types called "vertical" (parent to child), "horizontal" (between members of the same generation), and "oblique" (anything else) according to current epidemiological usage.

With these simple distinctions Cavalli-Sforza and Feldman are able to specify mathematical models that confirm the intuitively plausible principle that the number of transmitters per recipient affects the rate of cultural change. Thus, when the ratio of transmitters to recipients is large (many to one, as with stratification into social classes or castes), change may be slow. When the ratio is small (one to many, as in the case of social leaders using mass media), change may be fast. Similarly, the age relations of relevant social networks can affect the rate of evolution: when grandparents or other elders teach children, cultural change will be slower than in the case of horizontal interactions like those among sibs and other age peers.

The authors proceed by adapting classical population genetic models so that they are appropriate for cultural transmission that is not constrained by Mendelian rules. For example, vertical inheritance of a dichotomous trait (for example, Republican or not) is specified by considering the four possible types of mother-father matings. The frequencies of each of the four mating types and their probability of producing a Republican child are denoted by eight parameters. Assuming that the coefficients of transmission are constant across individuals and across generations, observations to estimate the eight parameters permit evaluation of the kinetics of the recursion system defined by the model.

Oblique transmission and horizontal transmission of discrete traits involve a function of both the probability of contact in an extended social network and the conditional probability of cultural change given contact. Thus, nonvertical transmission is intrinsically frequency-dependent. Combinations of vertical and nonvertical inheritance and the kinetic effects of various evolutionary forces are considered in detail. Extensions to discrete traits with more than two states are also provided. The most important conclusion from the stability analyses of discrete traits is that stable internal equilibria are frequent under vertical transmission; that is, cultural traits are likely to have multiple forms at any one time. In contrast nonvertical transmission is usually associated with a flux of innovations that are rapidly accepted and rapidly replaced.

Cultural transmission of continuous traits is formulated in terms of linear models that take into account differential contributions of the two parents, some types of assortative mating, social stratification, and the various evolutionary forces mentioned earlier. There is a cogent discussion of historical ideas about "blending" and "particulate" inheritance. The key result is the intuitively plausible conclusion that the stabilization of cultural variance within a population is intrinsic to the process of cultural transmission itself. More specifically, as long as there is learned transfer of information across generations, the cultural variability within a group reaches a finite upper bound that is a small multiple of the mutation variance. Also noncommunicating groups diverge under cultural drift linearly with time.

Although relevant data are scanty, the applications of the models are illustrated with many interesting examples about the spread of infections like kuru and hepatitis and about the evolution of surnames and languages. Because of the dearth of adequate data about cultural traits, the authors and their colleagues also collected questionnaire data about some behaviors and beliefs of Stanford University biology students. These data are extensively used to illustrate the models. Unfortunately, any interpretation of them is dubious because of a low response rate to the survey and the lack of test-retest reliability data. Furthermore, interpretations of all the data analyses are questionable because the models neglect gene-environment interaction and individual differences in learning ability.

The work of Cavalli-Sforza and Feldman on cultural transmission has already had a major impact directly in theoretical population biology and indirectly in behavior genetics. This new synthesis of their decade of effort demonstrates that it is possible to extract the answers to many key mathematical questions about cultural transmission despite cautious modeling assumptions. Nevertheless, geneticists will be greatly disappointed that they have deferred treatment of individual differences and gene-environment interaction. Social scientists will be disappointed that the integration phase of cultural change has been neglected. Perhaps the analogy between cultural and biological evolution could be extended usefully to consider cultural epistasis and cultural speciation. However, it is more likely that we need to know more about the mechanisms of cognitive development, behavior genetics, and socialization before further mathematical modeling of cultural evolution can be fruitful.

The book is highly recommended for mathematically oriented scientists, especially population biologists and economists. Its prose and logic are lucid, but its emphasis on stability analysis may be tedious for many social scientists and nonmathematicians. The book could be used as an introduction to population genetics for social scientists with the appropriate mathematical prerequisites, including matrix algebra and stochastic processes.

Overall, Cavalli-Sforza and Feldman have given us a sound mathematical foundation for the study of cultural evolution. Much exciting empirical and theoretical work remains to be done.

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Primate History

Evolutionary Biology of the New World Monkeys and Continental Drift. Proceedings of a symposium, Bangalore, India, Jan. 1979. RUSSELL L. CIOCHON and A. BRUNETTO CHIARELLI, Eds. Plenum, New York, 1980. xviii, 528 pp., illus. $49.50. Advances in Primatology.

This book is the expanded proceedings of a symposium held during the seventh congress of the International Primatological Society. The major problems addressed are the questions of platyrrhine origins and the relationship of platyrrhines to catarrhines in light of plate tectonic theory. Illustrating the complexity of these problems is the diversity of topics discussed: geological and geophysical evidence relating to paleogeography; the biogeography of Tertiary land mammals; the primate fossil record; and primate dental, cranial, postcranial, integumentary, developmental and reproductive, karyological, and biochemical evidence relating to platyrrhine origins. Behavioral and paleoclimatological evidence is not presented.

Nearly all the authors deal completely with biological evidence, giving passing mention to plate tectonic evidence that supports one or another phyletic argument. Tarling's paper, however, deals wholly with plate tectonics and the possibility of Cretaceous and Tertiary land faunal transfer to and from South America. One problem that I see with his reconstructions is that, although contact between the plate margins took place until the late Albian between the Falkland Plateau of South America and the Cape region of Africa, subaerial conditions cannot yet be proven, and this land route remains hypothetical. Tarling also postulates that Tertiary sweepstakes dispersal routes between Africa and South America could have existed in the northern, equatorial South Atlantic. He avers that oceanic islands hundreds of square kilometers in area existed offshore of Brazil and West Africa until the end of the Eocene. The original reports of the volcanic origin and structure of the Ceará and Sierra Leone rises in this region yielded no samples indicating subaerial conditions. Sweepstakes dispersal of organisms across the late Eocene South Atlantic is therefore advanced as more likely than available evidence seems to warrant. Tarling's further reconstruction of parts of the Mid-Atlantic Ridge widely exposed by a fall in sea level during the beginning of the Oligocene results in the marine barrier between South America and Africa being transected by hypothetical emergent structures. The result is that many authors in the volume unhesitatingly use Africa as a source area for both platyrrhine primates and caviomorph rodents, sometimes postulating a multiple series of invasions (Chiarelli, Sarich and Cronin).

The majority of authors hold that higher primates arise from omomyids, but adapids (Gingerich) and tarsiids (Cartmill) are also advanced as the anthropoid ancestral group. I was confused by the fact that Delson and Rosenberger use "protoanthropoid" to refer to a basal anthropoid, rather than to a prosimian stock ancestral to anthropoids. Most of the authors emphasize platyrrhine monophyly, but Chiarelli on karyological studies and Perkins and Meyer on integumentary traits are exceptions. The latter two authors suggest that adapid prosimi-