erate under different metabolic conditions. These functional differences appear to have developmental and evolutionary consequences. Differences in localization of the lactic dehydrogenases within a single cell (*6*) might also be stressed. Thus, the tertiary structure of a macromolecule may be modified by its incorporation into the three-dimensional framework of the cell. Such localization to specific cell sites could restrict the randomness of the system. In *Tetrahymena* the esterases and acid phosphatases are "particulate" bound (*3*, *5*). In the case of the esterase isozymes a differential localization of members of the isozymic set occurs. Mutation may even affect an isozyme by shifting its position in the cell (*7*).

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The Individual in History and in Cultural Evolution

The recent article by Thomas Kuhn, "Historical structure of scientific discovery" [*Science* **136**, 760 (1962)], has some significance for cultural evolution as well as for history, particularly in its discussion of the importance of the individual in discovery. There is an established tendency in historiography to segment the past arbitrarily into units that coincide with the lives and accomplishments of great men. Besides being a useful means of ordering the narrative, this tendency reflects the well-inculcated feeling that the individual is of prime importance in "shaping" the course of events.

For defining and describing specific things and events of the past—in their structural aspects—the historian finds this diachronic segmentation not only convenient but advisable. The past must

be tied to those who lived it. It is with this realm of description that Kuhn is concerned, and it is on the formal difficulty of matching a discovery to a single discoverer that he focuses his attention.

The scholar who is concerned with the *functional* ordering and explaining of events of the past, whether he calls himself historian or cultural evolutionist, can ill afford this emphasis on the individual, for he is dealing with a process that transcends the individual. Kuhn was not concerned with the evolutionist approach, but his admonitions nevertheless concern the cultural evolutionist.

The things and events of the past can be described—and this we usually think of as the historian's task—or they can be explained through analysis of the network of antecedent events. Such an explanation, whether it deals with specific historical facts or general trends, constitutes an approach to the past that is qualitatively different from description. It is not in content but in context that the two approaches differ. And in both it is dangerous to attribute a discovery entirely to the genius of the individual who brought it to scientific light. For the historian describing or defining a historic situation, Kuhn's objections are well taken; for the student concerned with the developmental pattern—with cultural evolution—the danger is the anthropocentric fallacy of citing the individual as the moulder of culture. In this context the individual is the instrument of the culture. One should not attribute cultural events to his instrumentation. The discoverer or inventor, however enlightened, does not explain the development.

It is a fact of history, for example, that James Watt developed and patented the first true "steam engine" in 1769. Here the descriptive historian has little difficulty. But this innovation did not occur simply because Watt was there to give it birth, as a mere statement of the event might imply. It can be attributed only to the cumulative and directional flow of the process of cultural evolution. These attributes of the process—cumulation and direction—remove it from the sphere of fortuitous occurrence and give it scientific meaning. Barzun (*1*) illustrates both in his treatise on the evolution of evolutionary thought. Darwin, he shows, was the point of articulation of the cultural process, not its instigator. The process had reached a consummation in time (*1*, p. 33): "Earlier . . . a new scientific

theory would have reached but a small circle of readers. Later, it would have been lost amid the clatter of front-page headlines." White (*2*) has made the relationship of the discoverer to the process of discovery explicit: the discovery or invention is explained (*2*, p. 170) "in terms of a growing and interactive culture process; the individual inventors or discoverers are merely the loci and vehicles of this process." And Kroeber examined the difference long ago (*3*): "the content of the invention or discovery springs in no way from the makeup of the great man . . . but is a product purely of the civilization. . . ." There are always many other enlightened individuals on hand to bear the torch of discovery if the Watts and Darwins are not available.

Despite Kuhn's emphasis on the individual vis à vis the discovery in descriptive history, he said much for the student of cultural evolution regarding the individual vis à vis his cultural milieu. Slanted emphasis in either case can easily spotlight the personality and obscure the process.

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Since I had intended my article to be read as a plea for what Wetherington calls the "evolutionist approach," I can only gratefully agree with most of his comments. In one respect, however, I find his letter troublesome. Let me here restrict my attention to it.

Wetherington seems to imply that there are two distinct approaches to the analysis of historical development—one structural, the other functional—each with its own strength and dangers. Applied to the problem of discovery, the structural approach is the one that attributes a discovery to the man who made it, while the functional approach suppresses the role of the individual in favor of the cultural milieu. Thus, to say that "James Watt developed and patented the first true 'steam engine' in 1769" is for Wetherington an example of the structural approach. In the functional approach one would study the evolution of the steam engine from the background of social needs and craft techniques supplied by the Industrial Revolution.

But are there really two approaches? Only by defining Watt's engine as the first "true" one can one transform Wetherington's structural statement into "a fact of history." Even with that definition, one would have difficulty justifying the date 1769 as the year of the engine's development. The sort of statement which Wetherington employs to illustrate the structural approach is, more often than not, simply a mistake. On the other hand, to say that discoveries normally evolve with time is not to say that individuals have a negligible role in their evolution. Nor is it to say that the evolution of each and every discovery must be studied against the entire cultural ambiance of the day.

Given any particular discovery, it is a historical problem—perhaps *the* historical problem—to discover whether and how the individual interacts with his milieu, and with which parts of the milieu he interacts, in the evolution of novelty. There is no single answer. Studying different discoveries, the historian will find many different sorts and degrees of dependence. But it is the discovery that varies, not the method of study. Call that structural, functional, neither, or both, the historian can neglect the individual or his milieu only after research has shown that one or the other played a negligible role in the development of the episode that concerns him. Structure and function will emerge together from that research. They are not to be had separately.

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Interpretation of Cation-Exchange Mechanisms

In their report, "Course of cation absorption by plant tissue" [*Science* **136**, 1051 (1962)], E. Epstein, D. W. Rains, and W. E. Schmid discuss in terms of an "enzyme-kinetic" model experimental data of constant absorption rates depending exponentially on temperature. The authors conclude: (i) the overall mechanism of cation absorption (not further defined) possesses a "high degree of irreversibility"; (ii) absorption is metabolically mediated; (iii) the cation-exchange capacity (labeled general, nonselective) is largely satisfied by calcium under physiological conditions; (iv) the time course (the rate?) of the absorption of monovalent cations under these conditions is precisely like that of anions; (v) "overt, nonselective cat-