The hedgehog and the fox – two styles of science

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“The fox knows many things, but the hedgehog knows one big thing," the Greek poet Archilochus once said.

Perhaps Archilochus simply meant that the hedgehog’s single defense defeats the fox’s many tricks. Yet, the hedgehog and the fox were turned into metaphors two types of thinkers and writers by the historian philosopher Isaiah Berlin. All the thinking and action of the hedgehog revolve around a single vision and are structure by a single set of principles that the hedgehog holds to be universal. Foxes lack such central vision and universal principles; they seize many experiences and pursuit many ends, always holding concrete particulars to be paramount. Each way of thinking has its strength and weakness; neither is superior to the other. Berlin cited Plato, Dante, and Dostoevsky as hedgehogs; Aristotle, Shakespeare, and Pushkin foxes. Tolstoy was diagnosed as a fox who imagined himself a hedgehog.

The metaphor of the hedgehog and the fox can also be applied to two styles of science. Generally, the theoretical sciences with their penchant for generalization are hedgehogs; the historical sciences with their emphasis on particulars are foxes. Within theoretical science, elementary particle physics is the prime hedgehog, whose whole effort gravitates toward the fundamental building blocks of the universe. Chemistry, biology, condensed matter physics, and economics are foxes. Evolutionary biology, I think, is somewhat like Tolstoy.

Sciences that try to wrestle with complex phenomena, especially those high organizational levels, tend to be foxes. Foxes lack a central vortex, but that does not imply their thoughts are incoherent, inconsistent, or entirely fragmentary. Just as Aristotelian philosophy has a cohesive core, a foxy science such as condensed matter physics does have cohesive principles. After all, condensed matter is made up of atoms with their nuclei and electrons, the motions and interactions of which are governed by the laws of quantum mechanics. The problem is that straightforward deduction from quantum mechanical equations does not proceed very far; calculations are soon stymied by overwhelming complexities of condensed matter phenomena. To overcome the complexities condensed matter physicists have to make idealizations and introduce new concepts. They do not try to find exhaustive theories covering all aspects of a kind of many-body system, system made up of myriad interacting constituents, nuclei and electrons. Such systems are too complicated and multifarious to be exhausted by any principle. Instead, scientists raise specific questions targeting some salient features and make simplifications to disentangle the targeted phenomena from other factors. The result is a host of models and regional theories explaining various aspects. These theories with limited scopes – the fox’s many tricks – are pragmatic rather than idealistic. They are gems with unsurpassed strong explanatory and predictive power within their limited domain. Although less glamorous than the “the theory of everything” and all but neglected by philosophers of science, they contribute no less to the progress in science and technology.

Evolutionary biology is somewhat like Tolstoy. It is a fox but is sometimes advertised as a hedgehog in the popular media. Its theoretical apparatus is rather weak, but is sometimes presented as a strong theoretical science capable of generalizing into far-flung areas such as sociology and psychology. Such claims, made by some evolutionist and promulgated by others, have been criticized by other evolutionists. E.g., Richard Lewontin, a leading evolutionary biologist, is also a strong critic.

Evolutionary biology is essentially a historical science. Its force rests on a vast amount of data, both fossil records and comparative morphology and genetics. It chief explanatory method is narrative. Natural selection serves as a guiding theme or a center of gravity in narration that pulls together many pieces of data, in the same capacity as the notions of revolution or industrialization in political or social histories. It does not have the status of a theoretical concept representing an evolutionary mechanism, because the idea of such mechanism remains intuitive and controversial. The difference between theoretical models and narrative themes is that theories support generalization to other areas while themes are tied to the particular narration.

However, it is popularly advertised as a hedgehog with a strong theory, panadaptationism, by which it tries to annex other areas, such as sociology and psychology. The controversy over sociobiology and more recently new social Darwinism is a reaction to the theoretical claim.

It has a theoretical side, mainly in population genetics. Its theories are most successful in accounting for the statistics of genetic shuffling, especially during sexual reproduction. They are much less effective in accounting for natural selection as an evolutionary mechanism or in teasing the relative importance of various mechanisms. During the last three decades, the causal efficacy of natural selection has been increasingly challenged by competing mechanisms, such as genetic drift and self-organization. Neither theoretical models nor experimental data have been able to determine the relative importance of these mechanisms. Intuitively, natural selection seems to be the only plausible explanation for the apparent adapted ness of organisms, but no satisfactory theoretical explanation exists. Notions such as adaptation have been severely criticized by leading evolutionists such as Richard Lewontin. For particular cases such the evolution of the horse, we can piece together fossils and geological data to generate specific narratives of natural selection. However, without theoretical models, we cannot generalize. Evolutionary biology is best regarded as a fox that thrives on particulars.