

Evolution and Medicine

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What has evolution to do with medicine, or medicine with evolution? To some, the answer is very little. To a patient in the grip of intense precordial pain, evolution is clearly irrelevant. So also might it seem to a child with measles. And for most of the history of medicine the connection has been inapparent. I say inapparent because although ever since Darwin the evolution of all living organisms has been accepted by biologists, there was no obvious way to adapt the principles of evolution to those of disease and medicine.

But in the 1930s the Modern Synthesis brought a rapprochement between evolutionary biology and genetics that, in time, promoted a reductionist analysis of both evolution and functional biology that has resulted in genomics. And, of course, the study of the pathophysiology of disease, itself an aspect of functional biology, has traversed the same path. Today, the scrutiny of all biology is devoted to describing the anatomy and function of the genes, as well as those of their protein products acting singly or in integrated modules and networks to fulfill missions of development and homeostasis. So, although evolutionary biology and pathophysiology are utterly divergent in their goals, they are examining the same object – life – from different aspects, but subject to the same rules. And if these diverse aspects of the same object are subject to the same rules, how can we say that they do not relate to one another, that they do not affect one another in ways that influence their outcomes? If we accept that they do, then we must ask whether natural selection and evolution are apparent in analyses of disease in ways that touch on diagnosis and treatment.

Evolution in Medical Education

The answer to the above question is, of course, natural selection and evolution are clearly apparent in those missions of medicine. Some examples follow.

a. *Genetic variation and disease*

The substrate for natural selection is variation; a non-variable species, lacking the capacity to evolve, would become extinct, so the mechanisms of repair that suppress the variation of new mutations are imperfect. Some of that which remains promotes imperfections in homeostasis and so disease, much of it lethal. This non-adaptive variation is the object of what biologists call "purifying" selection, which perhaps accounts for a human fecundity of 25 percent or less. The use of the word purifying may offend physicians who are dedicated to the preservation of life, not to its extinction, but by eliminating the "unfit" before puberty, selection protects the species.

b. *A definition of selection*

Perhaps one reason for our standoffish position in regard to selection and evolution is our perception of natural selection as a kind of *deus ex machina* that picks that which is beneficial and rejects that which is not, a concept that defies any physician's observation of the messiness of life. But so detailed is today's knowledge of cellular structure and function that the mechanisms of selection are open to study, defining them in the context of homeostasis and congruence with experiences of the environment. Disease is defined as a consequence of incongruence with some of those experiences, and medicine is perceived as an analysis of the selective states of individuals together with efforts to adjust them

in the patients' interest.

So we all live two lives: in one we are each an instrument of the welfare of the species; in the other we attempt to make a life for ourselves. Medicine engages with both; in the first, public health and preventive medicine undertake to adapt environments to the species, in the second, medicine attends to the consequences of incongruence in individuals. How could we imagine medicine to be any more engaged with natural selection?

c. *Medicine and evolution*

Natural selection is not evolution, so how is medicine engaged with the latter? It is the evolved individual who has the disease, and the form it takes is determined by the structure and function of the elements of the evolved and integrated individual. Options and constraints governing these elements of structure and function stem from the genes themselves, both individually and in combination, products of selection and evolution. These products are subject to variation, and together with the specificity of experiences of the environment, account for both particularity of signs and symptoms of disease and the range of all phenotypic differences.

This seems straightforward enough, but almost nothing about selection and evolution appears in such outlines of medical curricula as I have seen, nor in textbooks of medical subjects. Why not? Perhaps it is because it has been the medical tradition to appropriate from biology only that which seems most directly applicable to diagnosis and treatment. But now, when we know so much more about the details of phylogeny, development and metabolism, medical biology is becoming more of a piece with that of all organisms. For example, the gene mutations most damaging to human health are often of conserved genes, those we share with worms, fish, and insects, and which only a few years ago never entered medical thought. But now genomics is demonstrating the genetic intimacy of all life, and that the rules governing the most modest of all organisms govern ours too. Many years ago, well before genomics, Theodosius Dobzhansky, in a lecture to high school students observed that nothing in biology makes sense apart from evolution. A parochial version of this truth might read, "Nothing in the biology of disease makes sense apart from evolution."

It is not that the ideas of selection and evolution never arise in medicine or in medical education. They do, especially in the minds of those who think genetically. But what these fundamental concepts are not called upon to do is to act as the primary context within which medicine is taught. Evolution and selection are basic to genomics and genetics, and genomics and genetics are basic to variation and disease. Only by tracing physical signs and symptoms back through physiology, biochemistry, and molecular biology to genomics and genetic variations and their relationships to development and experiences of the environment can we grasp the origins and associations of the qualities of diseases and the logic of treatment and prevention. Without this progression the student is unlikely ever to grasp in full the meaning of disease - or of health either.

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