LETTER

The genome is the perfect imperfect machine

In a recent paper, Avise (1) challenges the latest incarnation of the creationists manifesto—intelligent design (ID)—by adopting the posture that the structure, expression, and control of the genome has sufficient flaws, and it seems implausible that it is the handiwork of an intelligent designer. Although I agree with Avise in most respects and applaud his courage and insights on such a controversial issue (at least in the general public domain), I would like to make a few comments concerning the structure of the genome, or at least, our current understanding of its structure and why that structure and control is the perfect imperfect machine.

The biological literature is replete with illustrations of complex networks of interactions describing the flow of information among compartments. Examples include biochemical networks, gene regulatory networks, physiological networks, ecological networks, etc. The common thread among all of these networks is that they are small world networks (SWNs), in which the number of connections is less than the number of nodes and most nodes are not neighbors, but each node can be reached from any other node by a small number of steps. Although our understanding of such fractal objects is far from complete, what we do know is that such structures are redundant, robust, resilient, and stable. Furthermore, they are highly resistant to random attacks but highly sensitive to targeted attacks (2). Such networks are not confined to biological systems, and the classic illustrations include the internet, airline traffic routes, and electric power grids. SWNs also self-organize as the internet, airline routes, and power grid did under the natural selection of the market place. There is no need to invoke an intelligent designer, because the system (biological or otherwise) will configure itself as long as a selective force is applied. These SWNs will be adopted, because they are better solutions than the alternatives (e.g., random networks), and the fact that most systems are SWNs is proof beyond reasonable doubt.

In one sense, SWNs are perfect machines, because they can adapt to the vagaries of change and maintain their internal structure; however, because they are vulnerable to targeted attacks, they are imperfect machines. This vulnerability underpins the numerous illustrations of human disease that Avise (1) uses to illustrate the imperfection of the structure. In other words, selection (natural or otherwise) will result in an SWN because this is the most resilient, robust, stable, and redundant system, but it also creates its own vulnerability. If I were the creator, I would organize the genome as an SWN, but the fact that the genome is an SWN does not mean that I am the creator.

Avise (1) smacks the ball back across the net, and I hope this discourse adds velocity (as a tennis player, he will appreciate the metaphor). He has demanded that the believers in ID explain the failures of the genome, and I believe the discourse here offers some explanations as to why the processes obviate the need for divine intervention.

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1. Avise JC (2010) Colloquium paper: Footprints of nonsentient design inside the human genome. *Proc Natl Acad Sci USA* 107(*Suppl 2*):8969–8976.
2. Albert R, Barabási AL (2002) Statistical mechanics of complex networks. *Rev Mod Phys* 74:47–97.

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