Beatty's Sandcastles

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One time, my friend and I went rock climbing. We had with us a 60-meter rope in a bag. When we arrived at the crag and took the rope out of the bag, it was tied in horrifyingly complex knots that took us almost 30 minutes to untie. It had gotten to such a complicated state just from the motion of us swinging the bag as we hiked on the trail. My friend, a physicist through and through, made the comment, "I think this goes to show how incredibly complex systems arise from simple initial conditions and rules." When scientists formulate laws of the universe (e.g., the first law of thermodynamics, e = mc^2, and the theory of gravity), they hope to describe the fundamental rules of the universe in a simplistic way. In contrast, biology often looks at incredibly complex formulations. Yet when scientists formulate theories about biology (e.g., the theory of evolution, genetic drift, and ontogeny recapitulates phylogeny) they hope to capture this amazing complexity with simple theories. They hope to describe and predict the knots by theorizing about the swinging of the bag.

John Beatty succinctly examines this tension between the simplicity of laws and the complexity of biology, offering the "evolutionary contingency thesis" to explain the gap (218). The evolutionary contingency thesis claims, "All generalizations about the living world: a) are just mathematical, physical, or chemical generalizations (or deductive consequences of mathematical, physical, or chemical generalizations plus initial conditions), or b) are distinctively biological, in which case they describe contingent outcomes of evolution" (218). Put this way, biological generalizations are either able to be restated as fundamental universal laws of physics, or they are not laws at all since a law must be necessary rather than contingent.

From a) and b), we can deduce that there are in fact no biological laws at all, only contingent generalizations. Is this a problem? Currently, the lawlike status of theories such as evolution guides researchers in a Kuhnian fashion. Many biologists use evolution as a framework to guide their research. If current evidence does not fit neatly into the evolutionary model, efforts are made to explain the evidence in terms of the theory of evolution. Altruism, for example, seemingly defies the theory of evolution, which posits that the survival of species is a selfish endeavor by individuals. Altruism is a behavior where an organism, at no benefit to itself, aids another organism either of its species or of a different species. Is this evidence against evolution? Not necessarily, say biologists, since altruistic behaviors are likely to ensure the survival of a species, which will then be able to pass its genes on to the next generation, perpetuating the altruistic behaviors. If there were no biological laws available to explain this behavior, altruism, as well as a great many other evolutionary outcomes, would seem quite incomprehensible.

Does a contingent generalization in biology do the same work a biological law does? According to Beatty, not necessarily. "The problem with such rules is that they are so riddled with exceptions," says Beatty (224). Any taxonomist, geneticist, or undergrad biology student acknowledges that branches on the tree of life are ripe with life forms that appear paradoxical given an evolutionary explanation, such as egg-laying mammals, parasitic plants, and philosophizing primates. Any usable contingent generalization in biology would describe a pattern of evolution; however, because evolution is highly dependent on chance and randomness, such a pattern would be either highly reliant on specific initial conditions or non-ultimate, emerging as more of a shape resembling a pattern than any actual pattern. In either case, the resulting contingent generalization would have enough exceptions to be unable to do the work a law needs to do in science; that is, it would not be useful for describing future instances, and it might not even be able to explain present instances effectively.

So it seems like the acceptance of the evolutionary contingency thesis leaves us without biological laws and with no tools at our disposal to compensate for their absence. What does the evolutionary contingency thesis positively achieve then? Importantly, it allows us to reform our biological laws as mathematical, physical, or chemical laws. Consider entropy, which states that energy in a system dissipates, and entities go from order to disorder. This occurs simply because disordered states are more likely to occur than ordered states. For example, a sandcastle on the beach is in a state of high order, which it is very unlikely to achieve on its own. As it stands there over time, it will fall into disorder as the wind blows against it, waves crash into it, and children walk over it. As it falls into disorder, patterns of order will surely emerge – perhaps a square-shaped chunk of sand here, a spherical clump of sand there – but ultimately these are unlikely shapes to occur on their own, and so they will be few and far between. This will continue until the sandcastle is in its least ordered and most likely form – unorganized grains scattered on a beach. In this way, entropy can be characterized as a probabilistic statement that explains phenomena in the universe.

Now consider that this sandcastle is the history of life on earth, and biology aims to describe it. There are no laws, only pattern-shaped likelihoods that occur as the energy dispersed at the beginning of time swirls and eddies into interesting and sometimes unlikely shapes over geologic time. A gas giant? Sure. A planet with a moderately stable climate? Alright. Deoxyribonucleic acids that replicate themselves? You betcha. The evolutionary contingency thesis allows us to redescribe our biology as physics, reforming biological laws as probabilistic or mathematical statements. This seems so appealing since so many of the laws in biology are math-based, such as Mendel's laws of classical genetics, the Hardy-Weinberg principle, or statistical formulae describing population dynamics. The evolutionary contingency thesis allows us to describe the vast complexity of biology in terms of simple fundamental mathematical laws of the universe. In this way, we can restate our old biological laws as mathematical, physical, or chemical statements.

Of course, this move from complex biology to simple mathematics requires that biology be translatable to mathematics with nothing lost in the translation. It also requires that mathematics be a fundamental force that describes the universe. In other words, the evolutionary contingency thesis at least requires a unification theory of science. A unification theory of science is a reductivist theory that asserts that all sciences are reducible to and unifiable under the umbrella of physics, in an idealized picture of science where all the physical facts of the universe are known. Disunity of science thinkers such as J.A. Fodor are skeptical of this assertion.

Fodor construes reductivism as the move from one set of proper laws of a "special science" (a special science is simply a non-fundamental science such as psychology or economics) to a set of proper laws of physics via the use of "bridge laws" (98). A proper law is an axiomatic or fundamental law in a science, and a bridge law is a law that contains elements of both the reduced science and the science it is being reduced to. For example, if we want to reduce biology to physics, we might do so by first reducing a biological law to a chemical law and then reducing a chemical law to a physical law. In this scenario, the chemical law is the bridge law, and the biological and physical laws are proper laws. Importantly, reductivism holds that we may use any number of bridge laws to reduce the laws of a special science to the laws of physics.

Fodor argues that this reductivist picture is too strong for the special sciences. Take Gresham's law in economics. Fodor claims,

> "I am willing to believe that physics is general *in the sense that it implies that any event which consists of a monetary exchange (hence any event which falls under Gresham's law) has a true description in the vocabulary of physics and in virtue of which it falls under the laws of physics.* But banal considerations suggest that a description which covers all such events must be wildly disjunctive" (103).

A law such as Gresham's law, though extant within the physical world, is not a law of physics as such. This much is obvious. However, neither is it reducible to a law of physics via any number of bridge laws, since to do so is to lose the entities involved in the economical law in the first place.

Economics posits additional entities such as dollar bills and stock markets, which seem to have little to do with physical entities such as planes and vectors. We simply can't get from laws that regulate the stock market to laws that regulate thermodynamics without losing anything in between, claims Fodor.

What bearing does Fodor's objection have on the evolutionary contingency thesis? Recall that acceptance of the evolutionary contingency thesis entails that all generalizations about the living world are either mathematical, physical, or chemical generalizations, or they are distinctively biological, in which case they are contingent generalizations. I have already analyzed the way we might use these distinct biological contingent generalizations as restatements of more fundamental mathematical, physical, or chemical statements to salvage a scientific approach to biology. However, Fodor might argue that we can save biology by appealing to its place among the sciences as a special science. The distinctively biological generalizations about the living world which Beatty calls contingent generalizations function as a set of proper biological laws, and by Fodor's argument above are not reducible to proper laws of physics by any number of bridge laws, since our set of biological laws posits entities that don't exist in physical laws except in a deficient sense. For example, entities subject to biological laws such as hypothetical common ancestors and phylogenetic trees of life are not reducible to laws about physical entities such as waves and particles.

While Fodor's objection is important for reductivism generally, it is not necessarily applicable to the evolutionary contingency thesis. Fodor's objection pertains to the reducibility of proper laws from a special science to proper laws of physics; the evolutionary contingency thesis posits that there are no proper biological laws. Beatty's strong claim is that there are no biological laws, only generalizations about the living world that are either mathematical, physical, or chemical, or contingent generalizations about biology. So under the evolutionary contingency thesis, we have laws that already belong to the set of proper laws of physics or are contingent generalizations about biology and thus don't fit the criteria for reducibility to proper laws of physics, since they don't belong to a set of proper laws of biology at all. Indeed, the enterprise of the evolutionary contingency thesis is not so much to reduce biology to mathematics as it is to restate it in terms of mathematics. For this to work, we don't need to consider the reducibility of sets of proper laws.

I have argued here that the evolutionary contingency thesis allows us to account for the disparity between seemingly simple mathematical laws and seemingly complex biological phenomena by restating our biological laws as mathematical laws and accepting that all other generalizations about the living world are contingent generalizations. Admittedly, this approach leaves modern biology in an awkward position, as it's unrealistic to assume biologists will suddenly proclaim, “Oh I get it! I've been doing math this whole time!” and leave their microscopes behind them in the lab. Not only is this absurd, it's also not what's called for. Methodologically, we may keep our old biological methods and theories, since these can be recycled as pure descriptions of contingent biological generalizations. Beyond this, how does biology look if we assume the evolutionary contingency thesis?

Adoption of the evolutionary contingency thesis certainly wouldn't herald any kind of Kuhnian scientific revolution for the field of biology. It doesn't posit any new biological theories, present evidence that counters current biological research, or explain various biological theories in a new or more cohesive way. It simply recontextualizes the work biologists have already done. Presenting evolution as a process of inherent randomness, as opposed to a Delbrückian process of species optimization, leads to alternative ways of presenting hypotheses that formerly might have been stuffed into the box of established biological laws. Let's consider our altruism example once more, but this time from an evolutionary contingency thesis perspective:

Suppose an individual of a species exhibits altruism, helping another member of its species at no benefit to itself. This may occur because the individual is genetically coded to exhibit altruism, since altruism perpetuates survival of the species. It may occur because the species has evolved a moral compass. It could occur because altruism is a learned behavior in this particular species. Neither of these latter hypotheses is any more plausible than the first, from an evolutionary contingency thesis perspective. However, each is as worth considering and testing as the first. When a science such as biology studies the vast complexity and diversity of all life on earth, it may benefit the science to consider a vast and diverse number of ways to go about performing science. This includes consideration of alternative hypotheses that seemingly “break the mold” or introduce randomness into the highly ordered system of scientific research.

Works Cited

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