cy 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.

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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, eforts are made to explain the evidence in terms of the theory of evolution. Altruism, for example, seemingly defes 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 specifc 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 efectively.

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* 

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