Chapter 1
Generalizing Darwinism as a Topic for Multidisciplinary Debate

Agathe du Crest, Martina Valković, André Ariew, Hugh Desmond, Philippe Huneman, and Thomas A. C. Reydon

Abstract The ideas Darwin published in *On the Origin of Species* and *The Descent of Man* in the nineteenth century continue to have a major impact on our current understanding of the world in which we live and the place that humans occupy in it. Darwin's theories constitute the core of the contemporary life sciences, and elicit enduring fascination as a potentially unifying basis for various branches of biology and the biomedical sciences. They can be used to understand the biological ground of human cognition, common behavioral patterns and disorders, and psychopathology more generally in psychology, psychiatry, and neuroscience. Perhaps the best known expression of this fact is Dobzhansky's famous dictum that "nothing in biology makes sense except in the light of evolution" (Dobzhansky T. Am Zool 4: 443–452, 1964: 449; Am Biol Teach 35:125–129, 1973: 125), and given that all

A. du Crest
Institut d'Histoire et de Philosophie des Sciences et des Techniques, University of Paris 1 Panthéon-Sorbonne, Paris, France

M. Valković
Institute of Philosophy, Leibniz University Hannover, Hanover, Germany

Radboud University, Nijmegen, Netherlands

A. Ariew
Department of Philosophy, University of Missouri, Columbia, MO, USA
e-mail: ariewa@missouri.edu

H. Desmond
Institute of Philosophy, Leibniz University Hannover, Hanover, Germany

Department of Philosophy, University of Antwerp, Antwerp, Belgium
e-mail: Hugh.Desmond@uantwerpen.be

P. Huneman
CNRS and Institut d'Histoire et de Philosophie des Sciences et des Techniques, University of Paris 1 Panthéon-Sorbonne, Paris, France

T. A. C. Reydon (✉)
Institute of Philosophy and Centre for Ethics and Law in the Life Sciences (CELLS), Leibniz University Hannover, Hanover, Germany
e-mail: reydon@ww.uni-hannover.de

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human behavior supervenes on some biological basis, evolutionary thinking has a vast scope even just in this regard.

1.1 The Problem: Generalizing Darwinism

The ideas Darwin published in *On the Origin of Species* and *The Descent of Man* in the nineteenth century continue to have a major impact on our current understanding of the world in which we live and the place that humans occupy in it. Darwin's theories constitute the core of the contemporary life sciences, and elicit enduring fascination as a potentially unifying basis for various branches of biology and the biomedical sciences. They can be used to understand the biological ground of human cognition, common behavioral patterns and disorders, and psychopathology more generally in psychology, psychiatry, and neuroscience. Perhaps the best known expression of this fact is Dobzhansky's famous dictum that "nothing in biology makes sense except in the light of evolution" (Dobzhansky, 1964: 449; 1973: 125), and given that all human behavior supervenes on some biological basis, evolutionary thinking has a vast scope even just in this regard.

However, there has long been the conviction that the significance of evolutionary thinking goes well beyond biology and the sciences of human cognition and behavior. Just consider the motto "survival of the fittest", Spencer's pithy redescription of the principle of natural selection: the phrase does not specify what entities are at play. There is some such struggle at play not just between organisms, but also between (and within) cultures, between norms, or even between ideas. In fact, Thomas Henry Huxley, sometimes better known as "Darwin's bulldog", had intuited by 1880 that "the struggle for existence holds as much in the intellectual as in the physical world" (Huxley, 1880, 15–16). Huxley anticipated how Darwin's theory of the "transmutation" of populations of organisms could also be applied to the transmutation of populations of technical artifacts, social institutions, moral norms, or economic entities.

It is difficult to say when such generalizations of evolutionary thinking moved beyond intuitions and were fleshed out in a systematic way. Arguably, after the publication of the *Origin* (1859), it was Darwin himself who realized that, because of its generality, the theory can be extended to explain phenomena beyond the non-human living world. The *Descent of Man* (1871) contained the first generalizations of the ideas in the *Origin* to the human mind and human culture. However, subsequent generations of naturalist thinkers sought to apply Darwin's theory more broadly and systematically: to the human mind, to human behavior, to human diversity and differences between groups, and to society (Richards, 1987). Prominent early examples include authors such as Herbert Spencer with respect to both the foundations of social science and applications of Darwinian ideas to societal issues (Spencer, 1876), William James whose functionalist approach to psychology was inspired by Darwin's (see Green, 2009), Torstein Veblen for economics (Veblen,

1898), and John Dewey with respect to pragmatic philosophy and education (Dewey, 1910).

Despite this initial growth of evolutionary approaches, it is only in recent decades that there has been an acceleration in the interest in using evolutionary concepts and models to describe and explain non-biological phenomena (for a recent overview, see Heams et al., 2015). The following non-exhaustive list gives a sense of how broad the variety of evolutionary subfields is:

- evolutionary economics (Nelson & Winter, 1982; Witt, 2003; Hodgson, 2019; Witt & Chai, 2019),
- evolutionary anthropology and cultural evolutionary theory (Boyd & Richerson, 2005; Mesoudi, 2011; Mesoudi et al., 2006),
- evolutionary sociology (Dietz et al., 1990; Blute, 2010; Hopcroft, 2016; Turner & Machalek, 2018),
- evolutionary psychology (Barkow et al., 1992; Buss, 1995, 2008),
- evolutionary literary studies (Carroll, 2004; Gottschall & Wilson, 2005),
- evolutionary archaeology (Maschner, 1996; Barton & Clark, 1997),
- evolutionary history (Stuart-Fox, 2002; Russell, 2011),
- evolutionary medicine (Nesse & Williams, 1995; Nesse & Stearns, 2008; Stearns, 2012; Rühli & Henneberg, 2013),
- evolutionary computation (Mitchell & Taylor, 1999; Eiben & Smith, 2015),
- evolutionary electronics (Zebulum et al., 2002; Haddow & Tyrrell, 2011),
- quantum Darwinism (Blume-Kohout & Zurek, 2006; Zurek, 2018)
- evolutionary epistemology (Popper, 1972; Campbell, 1974; Gontier & Bradie, 2021),
- evolutionary ethics (Ruse, 1986; Joyce, 2006),
- evolutionary aesthetics (Voland & Grammer, 2003; Kozbelt, 2017),
- evolution of science and technology (Hull, 1980, 1988; Basalla, 1988; Ziman, 2000; Brey, 2008; Mesoudi et al., 2013; Scerri, 2016).

Some evolutionary approaches today are primarily (and sometimes only) manifested as mere theoretical possibilities in journal publications. For instance, Quantum Darwinism is based on the idea that the collapse of the wave function is interpreted as a type of "natural selection" between the "fittest" quantum states. While this work is still ongoing, it seems fair to say that it has not burgeoned into a proper subfield of quantum physics—it lacks empirical support. In contrast, other evolutionary approaches have established themselves more forcefully; evolutionary psychology and evolutionary anthropology are prime examples. These approaches are much older, arguably originating with Darwin's *Descent* (1871), and have by today grown into subfields with all the corresponding sociological hallmarks: scientific journals, scientific associations, and even departments dedicated to the subfield.

Another distinguishing factor between these evolutionary approaches is that they do not all use evolutionary thinking for the same type of theoretical purpose. When evolutionary thinking is applied in philosophy – mainly in ethics or epistemology – the reason is that it can offer an analysis of moral norms or the concept of knowledge in a way that is wholly naturalistic, i.e., in a way that makes no reference to reasons

or rationality. Such evolutionary approaches in philosophy typically elicit strong resistance from more traditional ethicists or epistemologists who view evolutionary approaches as succumbing to the naturalistic fallacy where reasons and causes are confused.

By contrast, for disciplines in the social sciences and history, the attraction of evolutionary thinking is the hope that it can offer a solid theoretical and possibly even unifying foundation for a variety of branches of inquiry (Mesoudi et al., 2006). Historiography has traditionally been conceived of more as an art than as a science, with the core business of historians to weave narratives that help make sense of events after the fact. The idea that historians would attempt to construct predictive theories was once deemed to be so misguided as to only produce "intellectual monsters" (Danto, [1985] 2007: 15). Today, by contrast, scientific approaches to history such as cliodynamics are gaining traction, and with it, the attractiveness of evolutionary approaches to history has grown, despite reluctance of more traditionally inclined historians (e.g. Turchin, 2008).

This overview could give the impression that the history of the reception of evolutionary thinking has been one of a steadily increasing popularity. This has emphatically not been the case: the use of evolutionary thinking outside biology remains as contested as it was in its very inception. In the academic sphere, skepticism takes a more implicit or silent form, namely as a lack of enthusiasm or interest. For instance, in economics, evolutionary approaches were first formulated more than a century ago with Veblen's (1898) work, were picked up again by Nelson and Winter (1982) and more recently have found a strong advocate in the work of Hodgson and Knudsen (2010). Nonetheless, the economics that is considered "mainstream" receives epithets such as "Keynesian" or "Friedmanite" – not "Darwinian". Evolutionary economics is still categorized among the "alternative" or "heterodox" approaches in economics, together with "institutional economics" or "ecological economics".

Economics is an interesting test case to reflect on why evolutionary approaches should be more widely accepted in some domains of inquiry rather than others. Evolutionary economics is one of the oldest generalizations of evolutionary thinking to other domains, and so contradicts the thesis that only younger evolutionary approaches are the less well-established ones. Moreover, it is not that evolutionary thinking has had no influence on economics. Its indirect influence is especially noticeable in behavioral economics (following Tversky & Kahneman, 1974) because it relies on research into evolved cognitive biases. And once one delves deeper in the history of the two disciplines, economics and evolutionary theory become even more intertwined. Darwin himself was heavily indebted to the earlier work of economists such as Thomas Robert Malthus and Adam Smith. Later developments in evolutionary thinking, such as research into the evolution of animal behavior (following Maynard Smith & Price, 1973), were strongly inspired by game theory, which was first developed in relation to human economic behaviour. And the structural similarity or at least analogical similarity between core economical and evolutionary concepts seems impossible to miss: competition as a core concept in both domains; the market (vs. the environment); utility (vs. fitness); or learning

(vs. adaptation). Nonetheless, despite this long history of cross-fertilization, the standard type of explanation present in introductory textbooks on economics (see e.g. McConnell & Brue, 2008) continues to be more structurally similar to Galilean mathematical explanations with a small number of precisely definable variables (supply, demand, interest rate, money supply, etc.), rather than to Darwinian explanations involving complex, variable populations interacting with the environment and changing over time. In comparison to psychologists or anthropologists, fewer economists seem to have judged evolutionary thinking to be explicitly indispensable for their explanatory goals. Why precisely this is so, and in general, why evolutionary approaches have had stronger uptake in some domains of inquiry rather than others, remains an open question (which we will not be able to explore in the present volume).

If we move on from the sphere of academic and scientific enquiry, and consider the reception of evolution and Darwinism in the public sphere, this is where we find the loudest critical voices. The oldest, and perhaps still today the most widely known, example of skepticism towards evolutionary theory in public discourse is the debate between religiously motivated creationist views and proponents of evolutionary thinking. Creationist views range from invoking mere metaphysical possibilities – such as a hands-off Deism where divine intervention is limited to setting the universe in motion and then letting it run its own course – to Young Earth Creationism and Intelligent Design, which require a creative entity to explain everything that Darwin's theory explained (biogeography, embryology, distribution of fossils, etc.).

The debate with Creationism—then called "natural theology"--was the most prominent in Darwin's day. The idea that humans could have descended from an ape-like ancestor was almost immediately met with a mixture of derision and alarm. However, the origin of creationism also illustrates a fascinating if disturbing way in which evolutionary thinking was generalized in the political sphere. According to historians, some creationists' blanket rejection of Darwin had to do with the perceived connection between Darwinian thinking and eugenics of that era. Proponents of eugenics – which included many leading evolutionary scientists such as Galton or Fisher – presented their policy proposals as based on evolutionary science. Religiously motivated resistance to eugenics (Kevles reports that most of the organized resistance to eugenics in the U.S. was mounted by the Catholic Church: Kevles, 1985, pp. 118–119) was dismissed as short-sighted sentimentalism and misplaced altruism. There is much more to be said about the complex connection between evolutionary theory, creationism, and eugenics. Our brief discussion illustrates how scepticism towards evolutionary thinking was inspired by political and ethical considerations even in the late nineteenth century. And the perception that evolutionary thinking has political implications has remained strong to this day. Indeed, the generality of Darwin's theory has been said to make it a "dangerous idea" (Dennett, 1995), not just because it has the potential to upset traditional theories and revolutionize fields of science but also because it has a strong potential to be misused in the societal arena.

Nowhere has this been more on display than in debates about the genetic basis of evolutionary change. The old eugenicists were strong genetic determinists, believing that genetic material determined a person's cognitive abilities and temperament This view was soon relegated to the status of pseudoscience as the field of genetics developed after the rediscovery of Mendel's work (independently by Hugo De Vries, Carl Correns and Erich Tschermak) in 1900. Consequently it was soon realized there is a strong environmental component to how genotypes are expressed in phenotypes. However, the idea that evolutionary theory could be used for betterment of the human species remained. One of the foundational texts of the Modern Synthesis, Fisher's *The Genetical Theory of Natural Selection* (1930), not only succeeds in combining Mendelism with the theory of natural selection (with the help of statistics), but also goes on, in the second half of the book, to apply this new theoretical understanding to further eugenic ends.

The current consensus follows Lewontin (1974) cautioning against interpreting measures of heritability as evidence for genetic heritability. Nonetheless, debates about the relative contribution of genes to development of human phenotypes, and especially for certain human properties such as intelligence, remain very sensitive today, especially because the echoes of the excesses of eugenics still resound. In the 1970s and 1980s a debate erupted following the publication of E.O. Wilson's book, *Sociobiology* (Wilson, 1975a; for the debate, see Allen et al., 1975; Wilson, 1975b, 1976; Sociobiology Study Group of Science for the People, 1976; Segerstrale, 1986; Wilson & Wilson, 2007). Wilson, an entomologist by training, refocused attention on the biological and especially genetic basis of human behavior – a focus that elicited criticisms of genetic determinism. Richard Hernnstein and Charles Murray's *The Bell Curve* in the 1980s and its statements about race and intelligence is an infamous example of the political and ethical implications certain types of evolutionary thinking can be perceived to have. Gould's response, *The Mismeasure of Man* (1982) remains a landmark for the critiques of abuses of genetics in social sciences. More recently, the advent of genome-wide association studies (GWAS), where not single genes but clusters of genes are linked to traits, has arguably given new impetus to more sophisticated forms of genetic determinism (see e.g. Comfort, 2018).

Another important example of how skepticism towards generalizations of Darwinism assume political-ethical dimensions is the advent of evolutionary psychology. In its standard form, evolutionary psychology models human cognition in analogy to a Swiss Army knife: consisting of modularized and automatic mental functions, shaped over tens to hundreds of thousands of years by natural selection (Barkow et al., 1992). The field has been criticized on scientific and conceptual grounds over the years, including by philosophers of science (Dupré, 2000, 2010; Buller, 2006; Downes, 2017; Smith, 2020) who question whether the evolutionary explanations constructed by some evolutionary psychologists actually constitute good scientific explanations. Other criticisms are ethical in nature, since modelling human cognition in this way – and in particular the modelling of some sex differences in particular – could give rise to forms of scientific sexism. In this way, it is feared that evolutionary explanations of human behavior resting on unwarranted

assumptions about human evolution could have profoundly adverse effects on society.

This state of affairs, where the remit evolutionary thinking has expanded well beyond its initial scope, and where evolutionary thinking continues to be perceived as having ethical or political import, gives rise to a number of questions that remain unanswered. This makes and that make "generalizing Darwinism" a topic for study and debate for and between philosophers and scientists, both between different disciplines and between scientists working in the same discipline. First, it raises philosophical questions on the nature of scientific explanation and scientific method. One set of questions concern the reduction of one domain to another and, more generally, about the relation between a theory in a given domain and its application to another domain. This leads to more specific questions concerning the nature of the reduction: do they rely on metaphors and analogies, on the existence of isomorphisms between domains, or something else? Second, it triggers questions about what role values (both epistemic and non-epistemic) play in science. Given the complex history of the reception of evolutionary thinking, as well as the different guises that "Darwinism" has assumed over time, there is also a strong historical component involved with reflecting about generalizations of Darwinism (for more discussion, see Desmond et al., n.d.).

One of the most fundamental open issues concerns what exactly the scope of application of evolutionary thinking is, and what it can be. The shared epistemological outlook of the evolutionary approaches mentioned above is that Darwinism can assume the role of a multi-purpose explanatory framework, or even a unifying paradigm, that could bring a diversity of fields of investigation both within and outside the life sciences together under a common framework. The shared epistemological outlook raises further questions whether there is also a shared ontology grounding that outlook. In that case, various phenomena, processes and systems under study in these various fields all instantiate the same basic process. Some have advocated for some nuclear form of Darwinian evolutionary theory that is to be filled in on a case-by-case basis for application to the various phenomena under study (cf. Aldrich et al., 2008; Hodgson & Knudsen, 2010). "Paradigm" here need not only refer to paradigms in the Kuhnian sense, but also to other notions such as Lakatosian research programs, Foucauldian *episteme's* or Holtonesque *themata*: all are candidate notions to capture the status of Darwinism as something more than a framework of metaphors or a heuristic that happens to be useful in all these fields.

To what extent are such epistemological views and metaphysical assumptions warranted? Are so-called "evolutionary" processes in societies and economies sufficiently similar to biological evolutionary processes to be explained in the same way, or at least in ways that allow them to be subsumed under an overarching evolutionary account? Many evolutionary approaches outside the life sciences rest on analogies between biological evolutionary processes and processes in society. The question then arises, how strong are the similarities between the various processes to enable the formulation of genuinely evolutionary explanations in the social and cultural domain? An important aspect of this question is what a complete evolutionary explanation of a biological phenomenon exactly should encompass:

what is the structure of evolutionary explanations and what components should a good evolutionary explanation have (Reydon, 2022)? Do all the various "evolutionary" fields provide such explanations? And if evolutionary explanations *can* be formulated in different areas of investigation, what follows for the unity and structure of the sciences – in particular, to what extent would evolutionary thinking be able to serve as a unifying paradigm for the life and social sciences, as some authors suggest (Mesoudi et al., 2006) and others have cautiously doubted (Reydon, 2021)?

A second cluster of problems arises from applying evolutionary thinking to humans and human societies. There is a difference, in this regard, between applying evolutionary thinking to – for instance – differences between male and female mate choice, and applying the same thinking to the collapse of wave functions. Understanding why precisely some generalizations but not others are perceived to be politically charged is not an easy task. Some theories such as the second law of thermodynamics, including its information-theoretic formulation, seems to be at least as generalizable. However, it seems reasonable to presume that any application of concepts such as entropy or mutual information to human behavior would not be perceived to have the same charged consequences that applications of natural selection are perceived to have.

A final cluster of problems that could threaten to bring any enquiry back to square one: what does "Darwinism" even entail (see also Desmond et al., n.d.)? The ideas introduced by Darwin underwent at least one major transformation in the 1920s and 1930s through the rise of the Modern Synthesis, which sought to unify natural selection with Mendelism by means of statistics (and many of the founders of the Modern Synthesis, such as Fisher, Wright, or Pearson, are also key figures in modern statistics). This yielded a precise mathematical approach to evolution, which however has been criticized for foregrounding genes and alleles and moving processes at the level of the organism, such as development, metabolism, or behavior, to the background (Bateson, 2005; Walsh, 2015). Recently the "Extended Evolutionary Synthesis" has been advancing an alternative view where the organism, through plasticity or niche construction, plays a more active role. Just how distinct the Extended Synthesis is from the Modern Synthesis, and to what extent it generates new predictions, remains a topic of active discussion. However, it does pose the question what precisely is being generalized when evolutionary approaches are advanced in new fields.

1.2 Aims, Structure and Content of the Book

The present volume aims to advance philosophical and theoretical work by providing an opinionated survey of the current state of the art in research on relevant topics in the life sciences, the philosophy of science, and the various areas of evolutionary research outside the life sciences. The volume aims to achieve more clarity on the epistemic potential of applying evolutionary thinking outside biology. To do so, the

volume does not simply follow the list of "evolutionary" fields mentioned above. Rather it collects work by researchers on the forefront of evolutionary approaches in a selection of fields. By bringing together chapters by evolutionary biologists, systematic biologists, philosophers of biology, philosophers of social science, complex systems modelers, psychologists, anthropologists, economists, linguists, historians, and educators, the volume examines evolutionary thinking within and outside the life sciences from a multidisciplinary perspective. It does not aspire to be exhaustive of the subject.[1] The chapters thus do not survey the entire domain of evolutionary approaches, nor do they all explicitly address the epistemological and ontological questions relating to generalizing Darwinism. Rather, as a collection they aim to provide readers with a sense of how diverse the 'generalizing Darwinism' domain is, and to examine the approaches that fall into this domain from various perspectives. While the chapters written by biologists and philosophers of science address theoretical aspects of the guiding questions and aims of the volume, the chapters written by researchers from the other areas approach the questions from the perspective of applying evolutionary thinking to non-biological phenomena. Taken together, the chapters in this volume do not only show how evolutionary thinking can be fruitfully applied in various areas of investigation, but also highlight numerous open problems, unanswered questions, and issues on which more clarity is needed. As such, the volume can serve as a starting point for future research on the application of evolutionary thinking across disciplines. In this respect, the volume does not only provide an overview of the current state of research, but also – we hope – will serve to motivate further work.

There are many ways to cluster the various contributions to reveal emergent themes. The following may be useful as a guide for the reader. We highlight four thematic clusters in the volume (that are reflected in the volume's table of contents).

[1] The volume originates in the expert workshop "Evolutionary Thinking Across Disciplines. Problems and Perspectives in Generalized Darwinism", which was organized by the volume editors at the *Institut des Systèmes Complexes* in Paris in October 2021. This expert workshop was the first event that was organized in the context of the project "The Explanatory Scope of Generalized Darwinism: Towards Criteria for Evolutionary Explanations Outside Biology" (GenDar), a research project located at the *Institut d'Histoire et de Philosophie des Sciences et des Techniques*, *CNRS / Université Paris I Panthéon-Sorbonne*, and the *Institut für Philosophie*, *Leibniz Universität Hannover*, and jointly funded by the *Agence Nationale de la Récherche* (ANR) and the *Deutsche Forschungsgemeinschaft* (DFG). The GenDar project closely collaborates with the Evolution and Social Science group at the University of Missouri, and the expert workshop in Paris was a joint event of this collaboration.

1.2.1 Part I: How Can Disciplines Benefit from, or Contribute to, Evolutionary Frameworks?

Psychology: In "Is a Non-Evolutionary Psychology Possible?" (Chap. 2), Daniel Nettle and Thom Scott-Phillips argue that the contentious debates in human psychology about the viability of the Evolutionary Psychology as an alternative to mainstream human psychology is based upon a false evolution/non-evolutionary dichotomy. Most, if not all, psychology investigates the functional design in organismal structures. And, since the presence of functional design pre-supposes an origin in evolution by natural selection, most, if not all, of psychology is evolutionary. The upshot is that psychologists can endorse evolutionary approaches to their investigations without necessary commitments to the most contentious parts of canonical EP.

Economics: In "Evolutionary Economics and the Theory of Cultural Evolution" (Chap. 3), Ulrich Witt argues that cultural evolutionists could help explain how innovative adaptations arise out of groups of agents by providing a theory of how individuals are motivated to search and adopt new activities. In exchange, economic theories could aid cultural evolutionists in explaining the prominence of intentionality. Witt proposes that human motivation serves as the mechanism for innovative expansion of resources which, in turn, produces a bias in the selective population that drives the evolution of innovative adaptations in the economy. In this way human motivations and intentions are the forces that shape innovative adaptations.

Humanities and literary studies: In "Repetition without Replication: Notes Towards a Theory of Cultural Adaptation" (Chap. 4), Carsten Strathausen argues that theoretical insights from extended evolutionary studies in the sciences and cultural adaptation studies in the humanities should serve as a basis for a theoretical framework for the study of cultural adaptation. Strathausen argues that previous attempts have been influenced by neo-Darwinian views on the scientific side, and a long-standing bias against statistical-quantitative approaches to culture, on the humanities side. Strathausen proposes replacing both traditions with a relationist approach inspired by the Extended Evolutionary Synthesis that analyzes the dynamic network of interrelated products, processes, and receptions by which artistic material is continually refitted into different forms for new audiences.

In "The Epistemological and Ideological Stakes of Literary Darwinism" (Chap. 5), Alexandre Gefen investigates the debates between humanist practitioners of cultural studies and literary Darwinists who advocate naturalizing literary aesthetic practices. Gefen finds that the virulent criticisms of evolutionary theorists hinder a serene examination of the disciplinary proposals put forward, in all their richness and epistemological ambitions.

Linguistics: In "Evolutionary Aspects of Language Change" (Chap. 6), linguist Johann-Mattis List presents important evolutionary aspects of language change which has not been adequately communicated across other disciplines that investigate human evolution. List then exposes current challenges of evolutionary studies in historical linguistics in light of these evolutionary aspects.

Education sciences: In "A Community Science Model for Interdisciplinary Evolution Education and School Improvement" (Chap. 7), education scientists Dustin Eirdosh and Susan Hanisch argue that a generalized conception of evolution provides a potential for engaging students in understanding the cultural evolutionary dynamics of their everyday lives, schools, and broader communities. They describe a model of Community-Based Cultural Evolution for inter-institutional collaboration at the intersection of evolution education and applied school improvement efforts. Their paper provides a conceptual foundation for exploring the claim that engaging students in reflecting on the cognitive, behavioral, and cultural evolutionary processes in their everyday lives provides new opportunities for school improvement and interdisciplinary evolution education initiatives.

In a follow-up chapter, "Teaching for the Interdisciplinary Understanding of Evolutionary Concepts" (Chap. 8), Hanisch and Eirdosh explore how understanding the structures of knowledge, or the organization of facts and generalizations in science, cognition, and education, may help illuminate the educational potential and evidence-informed pedagogical practices appropriate for teaching about the interdisciplinary application of evolutionary concepts.

1.2.2 Part II: Generalizations of Evolutionary Theory: Common Principles or Explanatory Structures?

Mathematical models: In "From Games to Graphs: Evolving Networks in Cultural Evolution" (Chap. 9), Karim Baraghith proposes a multi-level representation of cultural evolution that takes into account the various entities that evolve in cultures, from interactions between agents to the whole social networks that themselves evolve. Baraghith's representation is in the form of a mathematical model that draws upon game theory for representing the micro-level interactions and graph theory for the cultural macrolevel.

Ontological commitments: Gerhard Schurz in "Metaphysics of Evolution: Ontology and Justification of Generalized Evolution Theory" (Chap. 10) argues that the key for a successful abstraction and hence subsumption of cultural evolution into the domain of evolutionary theory is the common ontological commitments between biological and cultural evolution in terms of the entities and structures postulated: self-reproducing systems with variation and in which populations are located in environments with limited resources. The main difference between evolution and cultural evolution is that in the former genes are "constructors" of evolutionary systems while in the latter memes are "modificators".

Multi-level analysis: In "Human Social Evolution via Four Coevolutionary" (Chap. 11), Ted Koditschek proposes a novel framework for a new paradigm of investigating social evolution in scientifically defensible terms. The framework involves four analytically distinct but empirically nested levels (and logics) of evolution: a biological level that adopts the logic of natural selection, a cultural

level that advocates a non-reductive logic of cultural selection), a political level, grounded in a 'logic of domination', and an economic level, driven by a 'logic of capitalist competition' to track human evolutionary history up to the present day. Koditschek follows his account with a general assessment of the intellectual benefits that such retrodictive accounts of longue durée evolutionary history might bring to the social sciences.

1.2.3 Part III: Why Should We Be Skeptical of Generalizations of Darwinism?

Limitations for a generalized Darwinism for physics and chemistry: In "Is Natural Selection Physical?" (Chap. 12), Sylvain Charlat, Thomas Heams, and Olivier Rivoire ask whether evolution by natural selection could be applied to understand physico-chemical systems including the origins of life. They argue that in its common organismal formulations, it cannot, because it fails to recognize that biological evolution is a process that recursively modifies its own modes of operation. They provide attempts at a resolution of this issue.

Epistemic and moral risk: In "The Risks of Evolutionary Explanation" (Chap. 13), anthropologist H. Clark Barrett considers two kinds of risk in posting evolutionary explanations, the epistemic risk of providing false explanations and the ethical risk involved when those false explanations cause harm. Barrett warns that the perceived allure of evolutionary explanations along with academic incentive structures makes evolutionists particularly at risk of endorsing false explanations that have the potential for ethical harm.

Limits of Darwinian economics: In "Evolution and Ecology of Organizations and Markets" (Chap. 14), economist Randall E. Westgren examines the prospect of locating the evolution of economic organizations and markets within Generalized Darwinism though the investigation of Joseph Schumpeter's model of economic evolution form his 1939 book, *Business Cycles*, which features a complex combination of competition and selection processes within a community ecology of economic mutualisms, conventions, institutions, and other inter-firm structures that confound the explanation of the success of the variants. Westgren concludes that the selection and retention features of current accounts of Generalized Darwinism are incompatible with organizational evolution.

Limits of cultural evolutionary theory: Philosopher Simon Lohse in "Pluralism and Epistemic Goals: Why the Social Sciences Will (Probably) Not Be Synthesised by Evolutionary Theory" (Chap. 15) provides a critical assessment of a movement in the literature – lead primarily by Mesoudi and his colleagues – to synthesize the social sciences based on a theory of cultural evolution. Lohse proposes problems with the theory of cultural evolution that Mesoudi and others have proposed, and questions the epistemic value added to social sciences that their evolutionary approach offers.

Methodological limitations: In "Equations at an Exhibition: On the Cultural Price Equation" (Chap. 16), philosopher Tim Lewens considers the degree to which the Price equation serves as a useful analytic tool for the investigation of the evolution of culture. Lewens points out that in cases where a non-distorted distinction between selection and transmission cannot be made, the Price Equation is a misleading analytical tool. Unfortunately, the processes of cultural reproduction make a non-distorted distinction difficult. Hence, the Price Equation can mislead about cultural evolution.

Methodological limitations: In "Unlike Agents: The Role of Correlation in Economics and Biology" (Chap. 17), philosopher Hannah Rubin provides a cautionary tale in adopting ideas about evolution in biology and learning in economics, in particular, the tendency to think of measures of correlation as akin to attitudes of economic agents. The incautious practice leads to use of unreliable heuristics and misunderstandings in biology, as well as to misuse of biological results in economics.

1.2.4 Part IV: How Can Evolutionary Approaches or the Target Field Be Amended?

Revisions to the conception of inheritance: In "From the Modern Synthesis to the Inclusive Evolutionary Synthesis: An Einsteinian Revolution in Evolution" (Chap. 18), Biologist Étienne Danchin argues that recent developments in DNA sequencing and techniques that link DNA variation with phenotypic variation have revealed limitations to the mid-twentieth century "Modern Synthesis" conception of inheritance. It fails to incorporate the various genetic and non-genetic processes that are part of the inheritance system and hence provides an inadequate view of the full complexity of living organisms. Danchin provides an update which he calls the Inclusive Evolutionary Synthesis. His chapter reflects on historical developments and philosophical reflections on the twenty-first century science of inheritance as well as personal reflections about the challenges of endorsing IES.

Revisions to the evolutionary theory of development: In "Darwinian/Hennigian Systematics and Evo-Devo: The Missed Rendez-vous" (Chap. 19), Guillaume Lecointre argues that current formulations of "evo devo" are insufficient foundations for the study of morphological complexity of organisms. The field of Evo devo suffers from a false view that genes control body plans and an insufficient regard to the investigation of ontogenetic timing. Lecointre constructs a hierarchical graph of ontogenetic time segments which indicates when organs or other biological structures are present or absent. He argues such "ontophylogenetic" graphs are the real phylogenies that should be at the core of evo devo.

Incorporating a concept of agency: Philosopher Hugh Desmond in his "The Generalized Selective Environment" (Chap. 20), argues that a successful program of generalizing Darwinism to human social activities requires an answer to the

question, what constitutes the "selective environment" to which scientific ideas, moral norms, or corporations adapt? A successful answer provides a matter of degree contrast between natural selection and human agency. Attending to the features of the contrast help eliminate conceptual confusions running through the literature.

Incorporating a concept of agency: In "Adding Agency to Tinbergen's Four Questions" (Chap. 21), philosopher André Ariew and anthropologist Karthik Panchanathan argue that a large part of the lasting appeal to Tinbergen's four questions was (and still is) the methodological commitment to treating organisms as objects as opposed to purposive agents. While these features are still prized among today's biological social scientists, it ignores an important feature of many social organisms, that they are not merely objects, they are also purposive agents. Updating Tinbergen's four questions with agency in mind only makes them more applicable to the biological investigation of animal behavior, but it also strengthens the value and applicability of biology-oriented research programs in the social sciences.

Incorporating human behavioral ecology: In "Cultural Evolution Research Needs to Include Human Behavioural Ecology" (Chap. 22), Alberto J. C. Micheletti, Eva Brandl, Hanzhi Zhang, Sarah Peacey, and Ruth Mace employ Tinbergen's four question framework for the study of behavior and several case studies to distinguish between the questions that human behavioral ecologists answer from those who investigate cultural transmission. They assert that the field of cultural evolution can move forward and achieve greater synthesis by exploring how selective processes acting on biological fitness differ from those acting on cultural fitness – and how the two might interact in the cultural evolution of human behaviours.

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