MODERN SYNTHESIS - EXTENDED EVOLUTIONARY SYNTHESIS DEBATE: A PLURALIST SOLUTION

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ABSTRACT

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The latest challenge to mainstream evolutionary biology's Modern Synthesis (MS) is Extended Evolutionary Synthesis (EES). While EES supporters advocate for extending evolutionary theory with new empirical findings and newly developed theories in areas such as developmental biology and epigenetics, MS supporters remain content with the old theory, claiming that new empirical findings align with MS, so there is no need for an extensive overhaul of evolutionary theory. They deny the actuality of plurality in evolution based on unity and reduction. On the other hand, the EES side points out the plurality in evolution and demands a new synthesis that will include the newly discovered phenomena. For the solution of the MS-EES Debate, I advocated for Integrative Pluralism. Integrative Evolutionary Pluralism (IEP), inspired by integrative pluralism, represents the third, more stable yet unrealized path for evolutionary biology.

Keywords: Evolutionary Theory, Modern Synthesis, Extended Evolutionary Synthesis, Scientific Pluralism, Evolutionary Pluralism

ÖZ

MODERN SENTEZ - GENİŞLETİLMİŞ EVRİMSEL SENTEZ TARTIŞMASI:
ÇOĞULCU BİR ÇÖZÜM

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Genişletilmiş Evrimsel Sentez (GES), Modern Sentez (MS) olarak adlandırılan ana akım evrimsel biyolojiye karşı en son meydan okumadır. GES destekçileri evrim kuramının gelişim biyolojisi ve epigenetik gibi alanlardaki yeni deneysel bulgular ve yeni geliştirilmiş kuramlarla genişletilmesi gerektiğini savunurken, MS destekçileri ise mevcut kuramın yeni deneysel bulgularla uyumlu olduğunu, bu nedenle evrim kuramının kapsamlı bir şekilde yeniden elden geçirilmesine gerek olmadığını iddia ediyorlar. Tartışmanın MS tarafı, ünifikasyon ve indirgeme temelinde evrimdeki çoğulluğun gerçekliğini reddetmektedir. Diğer yandan GES tarafı ise evrimdeki çoğulluğa dikkat çekmekte ve yeni keşfedilen olguları da içerecek yeni bir sentez talep etmektedir. MS-GES tartışmasının çözümü için, entegre çoğulculuğu savunacağım. Entegre çoğulculuktan ilham alan entegre evrimsel çoğulculuğun (EEÇ), evrimsel biyoloji için üçüncü, daha istikrarlı ancak henüz gerçekleşmemiş bir yol olduğunu öne süreceğim.

Anahtar Kelimeler: Evrim Kuramı, Modern Sentez, Genişletilmiş Evrimsel Sentez, Bilimsel Çoğulculuk, Evrimsel Çoğulculuk

To Gülseren

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LIST OF ABBREVIATIONS

A	Aspect
DIY	Do-It-Yourself
EB	Evolutionary Biology
EES	Extended Evolutionary Synthesis
E	Explanation
EP	Evolutionary Phenomenon
I	Integration
IEP	Integrative Evolutionary Pluralism
MS	Modern Synthesis
OMS	Original Modern Synthesis
RA	Research Area
SET	Standard Evolutionary Theory
T	Specific Theory

CHAPTER 1

INTRODUCTION

Contemporary evolutionary biology still primarily operates within the confines of Modern Synthesis (MS), formulated during the early twentieth century. However, although limited, dissent against MS has been present from the beginning. Early incarnations of dissent have been successfully countered by the supporters of MS either by assimilating them into the existing framework, as in the case of the neutral theory of evolution (Futuyma 2023), or reducing it into an accessory theory, as in the case of the theory of Punctuated Equilibrium (Futuyma 2015). However, dissent has risen again during the first decade of the 21st century. A small group of biologists and philosophers has devised the latest incarnation of discontent with Modern Synthesis, known as Extended Evolutionary Synthesis (EES) (Pigliucci and Müller 2010b). After almost twenty years, EES, although marginal, appears to be here to stay. MS supporters' previous strategies of assimilating it and/or pushing the dissent into irrelevance have not been effective this time (Shan 2024). Furthermore, EES supporters are more numerous, well-organized, and well-funded than the previous dissenting movements within evolutionary biology. It must be admitted that EES-supporting publications still compromise a tiny fraction of what is published in evolutionary biology. The fate of the EES remains to be seen. However, it provides fertile ground for philosophical debate, such as the nature of scientific change and progress, specifically conceptual and theoretical change in science, and how scientific theories and paradigms are structured.

This thesis is based on two main arguments: one historical and one philosophical. The historical argument is based on the work of Vassiliki Betty Smocovitis, a leading historian of evolutionary biology, particularly in the context of modern synthesis. According to Smocovitis, the primary driving force for modern synthesis comes from the ideal of the unity of biology (Smocovitis 1992, 3–4). In this thesis, I aim to demonstrate that the urge for unification remains active in the MS-EES debate and suggest that we should overcome it.

The second argument of this thesis concerns what we should do instead of attempting to unify biology/evolution. This philosophical argument comes from Sandra D. Mitchell (2003), a leading philosopher of science who prescribes scientific pluralism instead of unification. Scientific pluralism is strong in the philosophy of biology, and pluralism in the context of evolutionary theory has been proposed numerous times before. So, my proposition in this thesis is not extraordinarily novel or unheard of. Philosophers of science from the inception of the EES movement suggested that pluralism might be applicable to evolutionary theory.

I implemented a specific kind of pluralism suggested by Sandra D. Mitchell, namely integrative pluralism, which is tailored specifically for complex biological and social phenomena. Although Mitchell applied her pluralist philosophy of science to evolutionary phenomena, curiously, she did not do it specifically for the EES-MS debate. To the best of my knowledge, this is this thesis's first novelty. Furthermore, the application of integrative pluralism led me to realize that MS and EES are not as different from each other as I initially thought. Both claimed to be a “synthesis” of evolutionary theories, which I consider a sign of their unificationist propensities. In this thesis, I reject the unificationist synthesis and advocate for applying integrative pluralism to evolutionary theory, leading to an approach I call Integrative Evolutionary Pluralism (IEP).

CHAPTER 2

HISTORY AND MODERN SYNTHESIS

In this chapter, I will present the historical argument of this thesis, which necessitates an examination of the history of evolutionary biology.[1] According to Smocovitis, one reason for the Modern Synthesis (MS) and the Extended Evolutionary Synthesis (EES) Debate is a simplistic, naive understanding of the history of evolutionary biology:

> Despite the fact that its advocates evoke history and use it as an important justification for extending the modern synthesis (MS), substantive engagement with the past is too often lacking, or often comes across as a convenient caricature instead of nuanced engagement with a complicated past. (Smocovitis 2023, 59–60)

In the following section, I will present Peter J. Bowler's (2009) historical account of evolutionary biology. I must note that it would be unfair to direct Smocovitis's criticism to Bowler's historical account as being a simplistic, naive understanding of the history of evolutionary biology. It is the most widely read and influential historical account of the idea of evolution and the

[1]. I must note that the historiography of evolutionary biology has also developed over the past few decades, and the previous historical narrative is currently being revised.

one most closely related to the understanding of the history of evolutionary biology by both MS and EES supporters.

2.1. Peter J. Bowler's historical account of evolutionary biology[2]

The prehistory of evolutionary thinking may date back to Ancient Greece, where the first traces of it can be observed, or it may have begun with Enlightenment France, where the first scientific accounts and theories of evolution emerged, and debates for and against them took place. However, many consider the theory of evolution to have become a real science with the publication of "The Origin of Species" by Charles Darwin in 1859. According to the traditional historical account, after Darwin's death, there was a period during which Darwinism lost favor among scientists, and many alternative competing theories emerged to account for the patterns and processes observed in the biological realm; this period is usually referred to as the Eclipse of Darwinism. In the early decades of the 20th century, Darwinism began to regain support, and with its synthesis with Mendelism, the Modern Synthesis emerged as the mainstream evolutionary theory.

2.1.1. Darwin's Contribution

Charles Darwin's most important scientific success was convincing the most educated people that evolution had occurred. However, he was unsuccessful in convincing them to accept his proposed mechanism for evolution, natural selection. Even his closest supporters were unconvinced that natural selection is the primary mechanism of evolution (Bowler 2009, 178).

[2] Thomas E. Dickins (2021, p. 51) refers to this as "the traditional account" because it was readily employed in criticisms of the Modern Synthesis.

Let us first examine the evidence for the evolution proposed by Darwin and his supporters. According to Peter J. Bowler (2009, 189), two botanists, one British, Joseph Hooker, and one American, Asa Gray, are the earliest supporters of Charles Darwin and his theory. Hooker wrote an essay to support Darwin's theory at the beginning of his book on Tasmania's flora in 1860; considering *Origin* was published at the end of 1859, it should be one of the first open scientific endorsements for Darwin. Asa Gray was the leading supporter of Darwin in the United States, and he utilized Darwinian evolution to interpret the distribution of plants in North America. Darwin's co-discoverer, Alfred Russel Wallace, was in Southeast Asia when the *Origin* was published. Upon his return to England, Wallace supported Darwin with his studies of the biogeography of animals in Southeast Asia. His study on Malayan butterflies supported Darwin's argument that distinguishing between the varieties and species is impossible. Ten years after the publication of *The Origin of Species* (1859), a consensus emerged among biologists that evolution is a real phenomenon (Bowler 2009, 196). However, Bowler issued a warning that the first phase of accepting evolution was not a straightforward process, as the evidence presented and the theory were accepted (Bowler 2009, 188). Considering that both the theory and evidence for evolution were complex and the backgrounds of the people who need to be convinced were heterogeneous, this should not come as a surprise: Some evidence is more effective on some people than others, and vice versa.

As I mentioned earlier, while Darwin's theory of evolution enjoyed general acceptance, his theory of natural selection as the primary cause of evolution experienced the opposite. Wallace, as the co-discoverer, was one of the few who accepted the central role of natural selection in evolution. However, Darwin and Wallace differed on two major points; the first one is the evolution of the human mind, which Wallace thinks cannot possibly be evolved by natural selection, while Darwin does. The second one is Darwin's other proposed mechanism for the evolution of some traits in sexually dimorphic species: sexual selection. While Darwin felt it was necessary to propose another mechanism for these curious traits, Wallace deemed it unnecessary and redundant as he thought these traits could also be explained by natural selection (Browne 2013). While Darwin and Wallace disagree about the scope of the theory of natural selection, others have raised several serious objections to it and rejected it altogether.

The first objection to natural selection was philosophical in character. Bowler (2009, 197-8) examines this philosophical debate. Darwin's opponents questioned whether he had used a proper scientific method to reach his conclusions or was merely speculating. Here, two philosophical perspectives on science clashed. According to Bowler, many expected a demonstration of absolute truth from Darwin for his theory of natural selection and insisted that natural selection could not be the *vera causa,* that is, the real cause of the origin of species. Supporters and opponents of Darwin have adopted two rival philosophies of science. While supporters of Darwin were in favor of John Stuart Mill's philosophy, which did not require direct observation of natural selection to be considered scientific knowledge. In Mill's philosophy, which aligns with British empiricism, the source of knowledge is the senses, and causes are merely "the constant conjunction between events" (Bowler 2009, 197).

On the other hand, Darwin's opponents favored William Whewell's philosophy of science, a rival to Mill's. Whewell's philosophy has idealist leanings; he and his supporters believed that "it was possible to intuit truths about nature ahead of empirical investigation" (Bowler 2009, 198). The reasoning of opponents of Darwin, as Bowler describes, involves a choice between strong intuitions that they themselves are certain of: God as the first cause, fixed species as His design, and the purposefulness of the Creation. Darwin’s complex and fragile speculative framework is no match for that (Bowler 2009, 198).

'The second objection Bowler notes against natural selection is the conviction that it cannot explain every observation in the biological world because not every trait is adaptive. If a trait has no adaptive value to the organism it belongs to, we cannot explain its existence by natural selection. Darwin took this criticism seriously and introduced another concept to explain non-adaptive evolution, which he called the "correlation of growth." According to the correlation of growth, two linked traits, one beneficial and the other not, can be carried out together by natural selection (Bowler 2009, 198).

The third objection to the natural selection theory in Bowler's list is related to the second one, which is that even beneficial traits should pass through early stages that are not beneficial to the organism. Because natural selection is powerless in these early stages, those traits cannot evolve through natural selection. The reply given to this objection by Darwin's supporters is that “most adaptive structures were not built from nothing but were modifications of a structure originally used for something else” (Bowler 2009, 199). This means that natural selection can co-opt existing structures into performing new functions by bypassing the need to create new structures for new functions from scratch.

One more objection regarding natural selection is the existence of very similar structures in dissimilar groups performing the same function, such as the eyes of vertebrates and cephalopods. The objection is how natural selection, relying on random variation, can possibly build similar structures within groups so far apart. Darwin’s response was that if there were only a limited number of ways a function can be performed, it was not surprising that it developed similarly (Bowler 2009, 199).

Another line of criticism is directed at natural selection's internal mechanisms, which is more severe than criticisms of its explanatory capabilities. Natural selection requires heredity to retain favorable variations for future generations. However, during Darwin’s time, very little was known about hereditary mechanisms, and what was known seemed to contradict the concept of natural selection (Bowler 2009, 199).

Darwin’s views on heredity reflected the prevailing scientific understanding of his time. In this pre-Mendelian era, blending inheritance was widely accepted. According to this view of heredity, an offspring’s characteristics will be a blend of their parents, much like mixing black and white paints, which results in the color grey. However, in a very influential criticism made by Fleeming Jenkin, this view of heredity is largely at odds with the inner workings of the natural selection mechanism. Jenkins pointed out that if parents' traits blend like paints in their offspring, new appearing variations will always be watered down and lost like a drop in a sea without any chance of establishing (Bowler 2009, 199-200).

Historical records show that Darwin was disturbed by Jenkin’s criticism. However, historians of science appear to hold differing views on how this disturbance impacted Darwin and his theory of evolution by natural selection. According to Bowler, while some historians believed that this push led Darwin to become more Lamarckian over time, others thought its effects on Darwin were minimal. Bowler himself suggests a possible way to save natural selection within a blending inheritance framework, provided that variation is continuous rather than the “sporting” kind; it is possible for natural selection to work with blending inheritance without new variations being diluted and lost (Bowler 2009, 200-201).

2.1.2. Eclipse of Darwinism

During Darwin's lifetime, his theory of natural selection met with serious opposition. After his death, although his theory of evolution was widely accepted, the situation worsened for his theory of natural selection. Julian Huxley named this period, which lasted until the modern synthesis, the "eclipse of Darwinism." It is worth noting that Julian Huxley also coined the term "modern synthesis" (Bowler 2009, 224). The Eclipse of Darwinism was one of a brushed-off period of the traditional historiography of evolutionary biology, which was depicted as a dark age of evolutionary science. Mayr describes this period as a "chaotic state" in which the science of evolutionary biology did not yet exist (Mayr 1993, 31). This may be the case for a Whiggish historiography of Darwinian evolutionary science. However, this period can also be represented as a Cambrian Explosion of evolutionary theorizing, albeit many short-lived theories developed during this period were anti-Darwinian or, more accurately, anti-selectionist. Although there were some overlaps and varied views within individual alternative theories of evolution, major currents of evolutionary theorizing during this period were as follows: neo-Lamarckism, orthogenesis, saltationism, and neo-Darwinism. Let us briefly summarize these different currents of evolutionary theories.

Neo-Lamarckism was a popular evolutionary current during the late nineteenth century. Even Darwin himself allowed the Lamarckian mechanism of inheritance of acquired characters into his theory. According to Lamarckism, characteristics acquired during an organism's lifetime can be transmitted to its offspring. The use or disuse of a body part by an organism results in the development or atrophy of that body part, which can be transmitted to its offspring. Darwin allowed this hereditary mechanism as an adjunct to his theory of natural selection. Neo-Lamarckians argued that natural selection was unnecessary and deemed the inheritance of acquired characters as the primary force of evolution. However, like Darwin, neo-Lamarckians were unable to find a hereditary basis for their theory. Also, new fossil discoveries that were more supportive of branching evolution undermined the Lamarckian cause because Lamarckians had predicted more linear evolutionary patterns. Towards the end of the nineteenth century, the popularity of neo-Lamarckism began to diminish (Bowler 2009, 236-44).

Orthogenesis was another current during the eclipse of Darwinism. In this perspective on evolution, variations arise due to an internal force within organisms. In this theory, evolution was linear and directed; however, the nature of directing inner force is usually not specified. Although the idea of orthogenesis influenced many neo-Lamarckians, it is much more incompatible with Darwinian evolution, where the interaction between an organism and its environment directs evolution. Bowler notes that supporters of orthogenesis were hostile toward Darwinian evolution, which, according to him, is another sign of the "continued influence of an idealist perspective in biology" (Bowler 2009, 247-8). Like Lamarckism, much of the supporting evidence for orthogenesis is rendered null by the development of paleontology (Bowler 2009, 250).

The separation between Darwinism and Lamarckism was not clear-cut during Darwin's lifetime. However, after Darwin's death, and especially with the developments in hereditary research, these two schools of thought began to antagonize. Especially, August Weismann's germ plasm model of heredity forbids the inheritance of acquired characters. Furthermore, Weismann insisted that there is only one possible way of evolution: "natural selection of random variation" (Bowler 2009, 251). This view of Weismann's is known as neo-Darwinism.

Another group of researchers known as biometricians also fell under the neo-Darwinian label. They tried to make sense of the problem of heredity by applying statistical methods to the variations observed in wild populations of organisms and the effects of selection on these variations. Biometricians believed that variations in organisms are continuous and represented these variations, such as height in humans, in a bell curve. They also showed that the selection can shift the mean value of a characteristic. Biometricians focused on populations instead of individuals, and this made them realize that variation and heredity are not opposing forces (Bowler 2009, 256-60).

The last current of evolutionism during the eclipse of the Darwinism period can be named several things: saltationism, mutationism, and Mendelism. Saltationists believe that instantaneous changes, referred to as mutations, can give rise to new species. The rediscovery of Gregor Mendel's findings reinforced the saltationist conviction. Saltationists dismissed Darwinian adaptation and natural selection as the primary drivers of evolution; instead, they viewed internal changes that affect developmental processes as key to structural changes within organisms. According to Bowler, Mendelians' disinterest in adaptation resulted from their research method, which focuses on studying small, controlled populations within laboratories (Bowler 2009, 261).

2.1.3. The Modern Synthesis

Until the start of the 1920s, hostility toward Darwin and his theory of natural selection prevailed, and theories opposing it enjoyed popularity among the scientific community. During the 1920s, the tide began to turn, and the so-called "eclipse" of Darwinism came to an end; the developments in the new science of genetics were largely responsible for this shift. First, it became clear that there was no possible way to incorporate traits acquired during an organism's lifetime into the particulate factors of heredity and pass them on to the next generation. This development undermined neo-Lamarckism. Second, realizing that mutations are random and not directed makes orthogenesis untenable. Lastly, when it became clear that mutations cannot make new species but only new variations, saltationist enthusiasm waned. Natural selection began to be favored again by both genetics and naturalists. These were the first signs of the second coming of Darwinism in the form of "evolutionary synthesis" or "Modern Synthesis" (Bowler 2009, 325).

However, historians and scientists disagree about the true nature and origins of the modern synthesis. The most widely accepted interpretation is that it is the "integration of the Darwinian selection theory and Mendelian genetics" (Bowler 2009, 326). However, one of the founders of modern synthesis, Ernst Mayr (1959), consistently disagreed with this interpretation and insisted that naturalists played a major role in embodying modern synthesis. For him, the modern synthesis represents the unification of several branches of biology. A more critical voice, paleontologist Stephen Jay Gould (1983), noted that the earliest versions of the modern synthesis were more pluralist and allowed non-Darwinian elements into the theory of evolution; however, subsequently, as the synthesis "hardened," these were eliminated (Bowler 2009, 326).

The first step toward reaching the MS was a reformed understanding of mutation. Saltationists believe that mutations can result in drastic changes that can lead to the formation of new species. However, Thomas Hunt Morgan's studies on fruit flies showed that mutations, which occur randomly, cause minor changes in the organism's characteristics. The effects of these minor changes can be quite variable; while some are inconsequential, others can be harmful. Furthermore, due to their minor effects, these mutations do not lead to a species change and can spread within the population through natural reproduction. Morgan, although initially opposed to the concept of natural selection at the start of his studies, realized that the spread of harmful mutations into the population would be limited due to their effects. However, any beneficial mutation could easily increase in number within the population, leading him to accept the idea of natural selection. However, Morgan's conception of selection is simplistic, as it does not consider the effects of recessive alleles (Bowler 2009, 328-9).

Another development was bridging the schism between Mendelians and biometricians about whether variation is continuous or discontinuous. Mendelians study a small number of characters with few alleles in laboratory conditions; however, in nature, many characters are formed by multiple genes, each with their own alleles. Realizing this fact made seemingly continuous variation possible with discrete hereditary units (Bowler 2009, 329).

These developments paved the way for modern population genetics, the foundation of the modern evolutionary synthesis. R. A. Fisher, J. B. S. Haldane, and Sewall Wright are considered the founders of population genetics, whose work was characterized by its mathematical nature.

Fisher's work was based on the insight that these new findings in genetics supported the biometrician's understanding of Darwinism. He mathematically showed that if a trait provides a reproductive advantage to individuals that possess it, its frequency will increase within that population. Conversely, if a trait is harmful to an individual's breeding success, its frequency will diminish. However, it will never become extinct if the gene that causes the trait is recessive. Fisher's models are applicable in large populations where individuals mate freely and selection operates uniformly. Haldane's assumptions were similar to Fisher's. However, he used concrete examples and showed that selection can be much stronger than Fisher assumed. Haldane's most famous example was melanism in peppered moths. However, Fisher and Haldane's assumptions of large and uniform populations were not usually what naturalists encountered in nature, as many populations are fragmented into smaller subpopulations by geographical barriers. Furthermore, they also assumed that genes are independently working units from one another, which also turned out to be unrealistic; this idea was later criticized as "beanbag genetics." Wright developed a mathematical model that works on small populations with interacting genes. He found that the best scenario for evolution is a large population comprised of fragmented, heterogeneous subpopulations. In this scenario, interacting genes will be fixed as a system within a small, interbreeding subpopulation and will be subject to natural selection. The selection that chooses the best adapted individuals to local conditions will gradually spread throughout the entire population. Wright's model also considers the chance events that occur in small sub-populations as genetic drift. Genetic drift can create adaptively suboptimal interaction systems that typically cannot pass through thresholds due to their low adaptive value. This explains how a species can go from one adaptive peak to another through a suboptimal low-adaptive valley (Bowler 2009, 330-3).

Due to their mathematical nature, Fisher, Haldane, and Wright's results were difficult for most naturalists to understand and interpret. However, they still convinced many naturalists to abandon Lamarckism and embrace natural selection (Bowler 2009, 334). Theodosius Dobzhansky's adaptation of Wright's work in his *Genetics and the Origin of Species* (1937) was crucial in converting most naturalists. In his book, Dobzhansky summarized the nature of mutations, their role in sustaining variation within populations, and Wright's techniques and mathematical results, and he also presented results from his work showing "the genetic basis of geographical variation in insects" (Bowler 2009, 336).

Although the role of population genetics in modern synthesis was crucial, Ernst Mayr, one of its founders, insisted that the naturalists were already returning to Darwinism during this period. Naturalists began to realize that it was time to abandon old typological views on species, as many species consist of subpopulations divided by geographical barriers and adapted to their own environments, making it impossible to decide which one is the true form of a species. Around the same time, paleontologists' reconstructions of past life implied that an "almost unpredictable" pattern resulted from interactions between organisms and their environments. Bowler states these developments provide a favorable environment for modern synthesis to flourish (Bowler 2009, 334).

The term "Modern Synthesis" originated from Julian Huxley's book *Evolution: The Modern Synthesis* (1942), in which he brought together various developments in evolutionary biology (Bowler 2009, 335). According to Bowler, modern synthesis matured in the mid-1940s; however, he adds to emphasize its disputed nature:

> What exactly had been achieved has been a subject of controversy ever since. The synthesis was certainly a revival of the selection theory and of a Darwinian perspective more generally. The major non-Darwinian mechanisms were eliminated, and the extent to which even a minor role for nonadaptive processes could be retained was disputed. (Bowler 2009, 338)

Also, Bowler (2009, 347) adds that after synthesis, there is no period of Kuhnian "normal science" where the non-revolutionary scientists do the menial job of "filling the details" of the synthesis; on the contrary, disputes continue among biologists, and "it has been possible to articulate divergent perspectives within the narrower frame of reference established by the synthesis."

Thomas E. Dickins (2021, 55) notes that, regarding the modern synthesis, if Darwinism was the thesis, Lamarckism, saltationism, Mendelism, and orthogenesis were the antithesis. However, in the resulting modern synthesis, only Mendelism and Darwinism were represented, and others were ignored. Mayr (1993, 31) even saw this exclusion of other ways of thinking about evolution as an important step toward reaching the modern synthesis. Stephen Jay Gould (2002, 505) refers to this as one of the two stages of modern synthesis. He names this first stage the restriction period and the second last step the hardening period.

In Gould's terms, during the restriction period of evolutionary synthesis, evolutionary theory focused on gradual genetic evolution and natural selection, which works on random mutation. According to Gould, although it was focused on genetics, there was still pluralism in this period. During the hardening period, natural selection became the primary force of evolution and the era of adaptationism began, characterized by the examination of phenotypes in terms of adaptation (Dickins 2021, 64).

Gould, in his "The Hardening of the Modern Synthesis" (1983), tried to illustrate this hardening of modern synthesis by examining the writings of three prominent figures of modern synthesis—namely, Theodosius Dobzhansky, Sewall Wright, and Gaylord Simpson—through time. Gould argued that the change in evolutionary theory during the hardening period, between the 1930s and the end of the 1940s, is more about intent rather than content. According to Gould, the original synthesis's main concern was mostly methodological: "It was primarily a plea for knowability and operationalism, for a usable and workable evolutionary unity" (Gould 1983, 74). Gould referred to this period as pluralistic because the founders were open to a diverse range of explanations regarding evolutionary change, unless they were "based upon known genetic causes operating within populations and laboratory stocks" (Gould 1983, 75). Gould observes that this pluralistic attitude gradually diminishes, and the content of one theory, Neo-Darwinism, is elevated to the supreme dogmatic position where "selection and adaptation were just about everything" (Gould 1983, 75).

This was the traditional account of the history of evolutionary theory, although it has been strongly challenged by the new historiographical studies. A simplistic understanding of this traditional account is fueling the ongoing MS-EES debate.

2.2. Smocovitis's Unifying Biology Narrative

Another historical narrative critical of the traditional account is Vassiliki Betty Smocovitis's. According to Smocovitis's account (1992, 1-5), the modern synthesis aimed to unify biology. Smocovitis traces the belief in the unity of knowledge from ancient Greece to Plato and describes it as one of the foundational aspirations of Western thought during the Enlightenment Period. During the early stages of modern synthesis, logical positivism was also reaching its heyday. Under the umbrella of the Unity of Science Movement, the logical positivists sought to unify and reduce all sciences to physicalist terms, employing a single common method. Furthermore, they also aspired to purge all sciences of their metaphysical elements (Smocovitis 1992, 7). All three architects of population genetics drew inspiration from the physical sciences (Smocovitis 1992, 20).

Smocovitis concludes that:

> The unified biology - through the central science of evolution as it emerged from the synthesis - would in turn be centrally situated within the positivist ordering of knowledge. Only within a positivist theory of knowledge, which then held sway, was the unification of biology, and the unification of science, desirable. (Smocovitis 1992, 3-4)

However, Mayr strongly disagreed with Smocovitis's assessment that architects were trying to recreate biology in the likeness of physical sciences and that their objective was to unify biology during the synthesis, although he agrees that this was the eventual result (Mayr 1993, 32-3).

CHAPTER 3

AN EXPOSITION OF SCIENTIFIC PLURALISM

Some philosophers who engaged in the MS-EES debate suggested a pluralist approach to evolutionary theory. In the edited book *Evolution, the Extended Synthesis* (2010) an early milestone in the debate, one of the philosophers contributing to the volume, Alan Love, mentioned a pluralist option for the theory of evolution. Love writes (2010, 403):

> ...the epistemological perspective offered here to answer these questions is explicitly *pluralist*. By this I mean that my aim is not to provide the one and only correct way of thinking about evolutionary theory, but rather to offer one fruitful possibility in direct comparison with others (cf. Kellert et al. 2006). There is more than one way to represent evolutionary theory, and among these alternatives there are different advantages and disadvantages.

As we will see further in this text, Love refers to Kellert et al. (2006), one of the influential pluralist formulations in the philosophy of science after the turn of the millennium, namely the *Pluralist Stance,* and asks for "direct comparison" with that formulation.

On the other hand, another philosopher contributor of the same volume, Werner Callebaut (2010, 443) writes in his contribution:

> The thesis of my contribution is that the evolution of evolutionary thinking (Hull 1988) since the making of the Modern Synthesis has been characterized by simultaneous unifying and disunifying tendencies,

> with no end in sight. This should be unsurprising, if not trivial, were it not for the claims of some postmodernists that unity is an ideological aberration, whereas disunity is welcome and real.

Callebaut's stance cannot be classified as pluralist because he sees the pluralist claims as postmodernist. However, the historical record of evolutionary biology appears to support Callebaut's claim of "simultaneous unifying and disunifying tendencies, with no end in sight." I tend to view this oscillation between unity and disunity as a forced unification returning to its natural state of disunity or plurality. Callebaut would likely classify this tendency of mine as "postmodernist" as well. Postmodernist or not, I also believe that pluralism, or evolutionary pluralism, is the way forward for evolutionary theory.

In this chapter, I provided a quick and focused exposition of the current pluralist philosophy of science. First, I refer to those who point to the plurality of science; second, I refer to those who claim that plurality is desirable. Next, I examined attempts to classify these multiplicities of pluralism. Lastly, I specified my weapon of choice, "integrative pluralism," which I examined in detail in the next chapter of this thesis.

3.1. Plurality: Disunity of Sciences

According to the *Stanford Encyclopedia of Philosophy* entry on "Scientific Pluralism," science is a complex epistemic and social practice that harbors multiple pluralities (Ludwig and Ruphy 2021, 1). As Ludwig and Ruphy elaborate, this plurality can be observed in every aspect of this social-epistemic enterprise, from the multiplicity of its disciplines and the diversity of its practitioners to its epistemic and ontological features, methods, and aims.

Although the pluralities of science have been evident throughout its history, until recently, both practitioners and philosophers of science have aspired to overcome this plurality to reach unity in science, however, these aspirations reached a dead end in the first half of the twentieth century, and during the 1970s and 1980s, some philosophers of science both accepted and embraced these pluralities and devised an explicit program of scientific pluralism (Ludwig and Ruphy 2021, 3).

However, as Ludwig and Ruphy (2021, 6) pointed out, understanding plurality in science did not occur instantaneously within the Western philosophical tradition. Instead, it is a process of realization within the postpositivist philosophy of science, informed by philosophical roots such as "American pragmatism, Neo-Kantianism, and early positivism."

In this thesis, I exclusively focused on the Anglo-American pluralist tradition for brevity and focus. This Anglo-American pluralist tradition has a starting point in the history of the philosophy of science: the Philosophy of Science Association Presidential Address (1978) given by Patrick Suppes with the title "The Plurality of Science." This tradition is known as Stanford School; members of this school are influential philosophers of science such as Patrick Suppes, Nancy Cartwright, Ian Hacking, John Dupré, and Peter Galison. After the turn of the millennium, a second wave of pluralist philosophers of science emerged within the Anglo-American tradition; these philosophers include Hasok Chang, Sandra Mitchell, and the Pluralist Stance of the Minnesota School, comprising of philosophers such as Stephen Kellert, Helen Longino, and C. Kenneth Waters.

Ludwig and Ruphy (2021, p. 7) view scientific pluralism as an attempt to reconcile the ahistorical philosophical analysis of science with its historicization, beginning with the historical epistemologies of Bachelard and Fleck, which culminated in the publication of Kuhn's *Structure of Scientific Revolutions* in 1962. Ludwig and Ruphy (2021, 7) see that two recent movements in the philosophy of science, namely "integrated history and philosophy of science" and "philosophy of science in practice," mark the mainstreaming of this approach in the field. Veigl (2022, 1) also sees scientific pluralism as “one of the household positions within philosophy of science and philosophy of biology in particular.”

Sandra D. Mitchell (2002, 55) succinctly writes that “[t]he ‘fact’ of pluralism in science is no surprise,” and then she points at manifestations of this plurality, "the multiplicity of models, theoretical approaches, and explanations." However, Mitchell (2002, 55) asks rhetorically, “if science is representing and explaining the structure of the *one* world,” how can this “diversity of representations and explanations in some domains” be possible? Mitchell (2002, 55) refers to one explanation of this question of the multiplicity of “representations and explanations” in science by the immaturity of these sciences. Thomas Kuhn (2012) made this “immaturity explanation” in his *The Structure of Scientific Revolutions*. However, Mitchell (2002, 55) objects to this explanation as there is no sign of diminishing multiplicity with the maturation of sciences, as the history of science shows us. So, Mitchell turns to the world itself, where her answer lies. For her, the reflection of the world's complexity causes multiplicity in science. Kellert, Longino, and Waters (2006, vii) agree that "some natural phenomena cannot be fully explained by a single theory or fully investigated using a single approach. As a consequence, multiple approaches are required for the explanation and investigation of such phenomena."

For pluralists, the plurality of science is apparent, so what are the sources of this plurality? There are at least four primary sources of plurality in sciences: ontological, epistemological, sociological, and methodological. Many philosophers of science, including Patrick Suppes, John Dupré, Nancy Cartwright, and Sandra D. Mitchell, highlight the features of the world, such as its complexity and its patchy or disorderly structure, which would hinder scientific attempts to describe and understand the world with certainty, completeness, and unity. However, not all pluralists have explicit ontological commitments. Instead, some philosophers advise restraint in making metaphysical assumptions, such as Stéphanie Ruphy's (2005, 118) "metaphysical abstinence" stance. Ruphy suggests:

> If philosophers want their arguments to remain relevant for scientific practice, I am afraid that they must be more modest about the status of these arguments: only temporally qualified arguments that stay clear of metaphysical contentions can usefully bear on discussions of the merits and limits of reductionist approaches in science. Metaphysics might be alluring in many respects, but it does not mix well with a taste for methodological prescriptions.

Epistemic sources of the plurality of science are also diverse; multiple kinds of representations in science, such as theories, models, and explanations, show plurality. Pluralist philosophers of science point out that the plurality in scientific practice is at odds with the unificationist aim of reduction. The reductionism debate was formative in the early years of the pluralist philosophy of science, which is dominated by debates on reductionism; however, in recent years, the focus of pluralists also diverted to other epistemic subjects, like "heterogenous relations between explanations, aims, models, practices, and institutions in scientific practice" (Ludwig and Ruphy 2021, 11). The epistemic claim of the pluralists is that scientific representations are always partial and contingent, which contrasts with the ultimate monist aim of reaching a single, all-encompassing view of the world (Kellert et al., 2006, xi).

There are two dimensions of the sociological aspect of scientific pluralism. The first is the less controversial dimension of the social organization of sciences into disciplines and scientific communities, which fosters scientific pluralism, and the second is the social diversity of society, which also leads to scientific plurality. This second one is more controversial due to its political nature. Although early pluralist philosophers of science focused on the metaphysical and epistemological aspects of scientific plurality, it became clear that one of the sources of scientific plurality is the relationship between science and society. Feminist philosophers of science are influential in this area of discussion, which underlines the importance of understanding the relationships between the social diversity of practitioners and the science they produce (Harding 2015, 126).

The idea that methodology is a source of plurality is uncontroversial; there is a multitude of methodologies within the diverse spectrum of scientific disciplines and fields.

3.2. Pluralism: Embracing the Plurality

Patrick Suppes was the first to embrace the plurality of science in his 1978 Presidential Address to the Philosophy of Science Association. In his manifesto, Suppes stated several reasons for embracing the plurality of science, including the irreducibility of the languages used in different scientific disciplines and their subjects of inquiry, as well as the lack of unity of method across these disciplines. However, except for a few, Suppes's manifesto did not gain widespread adoption (Kellert et al., 2006, vii). Although his manifesto was not influential initially, it is now regarded as the foundational point of the Stanford School of Pluralism.

3.2.1. Against the Unity of Science

Here, I must mention the Unity of Science Movement, the dominant ideal for science during most of the twentieth century, against which scientific pluralists had to fight. Also, I will briefly introduce the three concepts related to the Unity of Science Movement, which are directly in contrast with pluralism. These are reductionism, monism, and fundamentalism.

In its earliest forms, scientific pluralism was conceived in opposition to the Unity of Science Movement (Kellert et al. 2006, vii). Suppes (1978) presents a counterargument to the Unity of Science Movement. Suppes begins his manifesto with a section titled "What Is Unity of Science Supposed to Be?" in which he attempts to summarize the basics of the Unity of Science Movement, using block quotes from Neurath and Carnap. It is better to start with a more fundamental point where he describes the reason for the search for unity in science almost at the end of his paper:

> A common philosophical conception of science is that it is an ever closer approximation to a set of eternal truths that hold always and everywhere. Such a conception of science can be traced from Plato through Aristotle and onward to Descartes, Kant, and more recent philosophers, and this account has no doubt been accepted by many scientists as well. (Suppes 1978, 14)

In his paper, Suppes (1978, 9-11) focuses on three philosophical ideas related to the conception of the unity of science: (1) reduction, (2) search for certainty, and (3) search for completeness. Together with what he calls "unsupported dogmas" of certainty and completeness, the unity and reduction produce a "delightful philosophical fantasy." Suppes needed to criticize all these ideas to support his case for scientific pluralism. However, I will not go into details of the criticism of these ideas by Suppes. Since then, considerable attention has been devoted to these subjects, and discussions continue, particularly regarding the concept of reductionism. The importance of Suppes's manifesto for my thesis lies in its representation of a starting point for pluralism.

Although arguments for and against reduction are especially formative in the early years of pluralism, I choose not to get into the details of this debate because what is more important for my thesis is pluralism's stance against scientific monism and fundamentalism, which I will explain below. Furthermore, as we will see further in this thesis, my choice of pluralism among many kinds of pluralisms, the integrative pluralism, is not particularly against the reductionism, but rather sees it as an insufficient way to represent the complexity of the world, especially the biological world.

Since Suppes' manifesto, the case against the Unity of Science Movement has strengthened. For some, scientific pluralism has become the mainstream position in the philosophy of science and a favorable one, too. However, the idea of unity of science still lives among science practitioners and laypeople as a general attitude, as scientific monism.

Kellert et al. (2006, x) describe scientific monism in five points as follows:

> We take scientific monism to be the view that
>
> 1. the ultimate aim of science is to establish a single, complete, and comprehensive account of the natural world (or the part of the world investigated by the science) based on a single set of fundamental principles;
>
> 2. the nature of the world is such that it can, at least in principle, be described entirely or explained by such an account;
>
> 3. there exist, at least in principle, methods of inquiry that, if correctly pursued, will yield such an account;
>
> 4. methods of inquiry are to be accepted on the basis of whether they can yield such an account and
>
> 5. individual theories and models in science are to be evaluated in large part on the basis of whether they provide (or come close to providing) a comprehensive and complete account based on fundamental principles.

For scientific monists, the current state of plurality in science can be explained by its incompleteness; according to them, this plurality could be overcome through future developments. Scientific pluralists, however, do not see the current state of plurality in sciences as a deficiency. The pluralist objection to monism again highlights the complexity and indeterminacy of the world, and the diversity of human cognitive interests can be better served by a pluralist investigative and representational system (Kellert et al. 2006, x- xi*)*. As Chang (2012, 259) observes, "[m]onism is widespread among scientists, especially physicists."

Fundamentalism is a closely related concept to monism, which holds that all correct representations of the world can be derived from a few laws with the necessary empirical input (Kellert et al. 2006, xv). Pluralists again object to this idea by pointing out that the complexity of some parts of the world does not allow for a comprehensive representation of itself. Therefore, their representation cannot be derived from a single set of fundamentals (Kellert et al. 2006, xi*)*.

3.2.2. Plurality is Beneficial

Historically, prescriptive pluralism is represented by Paul Feyerabend, who calls for an anarchist approach in science in his book *Against Method (1975)*. A more recent supporter of this kind of attitude is Hasok Chang. Chang (2012) refers to his pluralism as "active normative epistemic pluralism." One of his arguments for pluralism is that having "multiple systems of practice" in the sciences is beneficial. Moreover, he identifies two categories of the benefits of pluralism: tolerance and interaction (Ludwig and Ruphy 2021, 19-20). Chang describes seven benefits of pluralism in science under these two categories. Under the category of toleration, he identifies four different benefits for science. These are 1) Hedging the Bet, 2) Division of Domain, 3) Satisfaction of Different Aims, and 4) Multiple Satisfaction. Under the category of interaction, there are three distinct kinds of benefits: 1) Integration, 2) Co-optation, and 3) Competition (Chang 2012, 270-284).

According to Chang (2012, 269), the benefits of toleration arise from a system that allows the "flourishing of multiple systems of practice," which is called tolerant pluralism. The following are the benefits of tolerant pluralism:

1) **Hedging the Bet:** This benefit of tolerant pluralism arises from the fact that science is an unpredictable activity. Here, Chang refers to Kuhn (1970, 206–207) for the unpredictability of the developmental path of science, Laudan's (1981) argument for pessimistic meta-induction, and Stanford's (2006) "problem of unconceived alternatives." These conceptions about science suggest that science is an unpredictable activity, and therefore, the most rational approach is to hedge our bets, which involves allocating resources to different systems of practice to minimize the risk of failure (Chang 2012, 270).
2) **Division of Domain:** For Chang, different systems of practice can cumulatively serve the same scientific aim, realizing more of it together rather than working alone. For example, a complex phenomenon is only partially represented by a theory; therefore, we need another theory to cover the other aspects of that phenomenon. This way, two or more theories can represent more complex phenomena than each can do alone. Chang likens scientific theories to tools in a toolbox; I will develop this toolbox analogy in the coming chapters:

    > In that respect, pluralism in science is just as natural as wanting to have various types of tools in our toolbox or having different types of shoes in our cabinet to suit different occasions. (Chang 2012, 272-3)

3) **Satisfaction of Different Aims:** The third benefit of tolerant pluralism arises from the fact that science does not have a singular aim; instead,

it is done with different aims by different practitioners or supported by external agents with different aims/purposes. Therefore, having multiple systems of practice to realize this multiplicity of aims is natural and beneficial (Chang 2012, 273-4).

4) **Multiple Satisfaction:** The last benefit of tolerant pluralism is that abundance is good. Chang notes that even if a singular system of practice can realize all three previous benefits for some phenomena, it is still preferable to have more than one; as Chang (2012, 276) states, "plurality enriches knowledge." Here, Chang asks us if we will stop doing science if we ever reach the truth about the universe or if we will start a new line of inquiry to tell the story differently. Here, Chang likens Science to Art.

The second set of benefits of pluralism arises from interactions among different practice systems. Chang calls this interactive pluralism. The following are the benefits of interactive pluralism:

1) **Integration/Integrative pluralism:** In some cases, even multiple systems of practice cannot cumulatively realize a scientific aim. In these cases, practitioners may attempt to achieve a better result by an ad hoc integration of different systems. Here, the ad hoc nature of the integration is essential for Chang, as it is necessary for a pluralist integration rather than a monist unification (Chang 2012, 279).[3]
2) **Co-optation:** Even without integration, different systems of practice can benefit one another by serving as a resource for each other. Another can borrow some elements of one system of practice to realize their aims. As Chang (2012, 280-1) suggests:

[3] The next chapter of this thesis examines integrative pluralism.

> In order to help achieve one's own aims, one may co-opt various types of elements from another system of knowledge: empirical results, theoretical ideas, mathematical techniques, instruments, materials, etc.

3) **Competition:** Philosophers of science have well-studied the competition among different scientific theories. However, they consider competition in isolation without theories interacting with each other. Chang points out that the actual history of science is different; competing theories or systems of practice interact with each other. Competition in science is not very unlike competition in sports or the economy, although it does not always have a positive effect (Chang 2012, 282).

3.3. Plurality of Pluralisms and the Pluralist Landscape

"It has been said that there are as many pluralisms as there are pluralists" (Chang 2012, 268). Philosophers known as Stanford School and other pluralist philosophers who follow them have varying views on how to ground their pluralism, the "extent" and "strength" of their pluralism, and the consequences of their pluralism (Kellert et al. 2006, x). This diversity of pluralisms prompted some attempts to classify differing views on pluralism. Ironically, but naturally, even these attempts contain some pluralism. I will now explain some of these attempts at classification.

Kellert et al.'s Pluralist Stance has a classification attempt of pluralisms that aims to distinguish their approach from others. It stands out as a reasonable middle way between too mild or too radical alternatives. So, there are three genera in the Pluralist Stance's classification. On one side are the modest interpretations, and on the other are the radical interpretations; Kellert et al.'s pluralist stance lies in the middle.

According to Kellert et al. (2006, xi-xii), modest interpretations of pluralism view the world as patchy, in which different phenomena coexist. Nevertheless, for every phenomenon, there should be one theory or model that explains it. Kellert et al. exemplified this pluralism with Sandra D. Mitchell's integrative pluralism and Philip Kitcher's pluralism. In Mitchell's case, although nature varies in its ways and for each of these pluralities, there should be one comprehensive account. Kitcher's pluralism is stronger than Mitchell's, where he permits different models or theories of the same phenomenon due to classificatory differences caused by various interests. However, he posits that all truths from different theories of the same phenomenon should be translatable to one another. According to Kellert et al. (2006, xii*)*, both Mitchell’s and Kitcher’s modest interpretations of pluralisms imply a kind of non-fundamentalist and/or non-reductionist monism due to their requirement for a single explanation for a single phenomenon.

At the other end of Kellert et al.’s (2006, xiii) spectrum are radical pluralists, exemplified by John Dupré's (1993) "promiscuous realism." According to Kellert et al., there can be an indefinite number of theories or models of phenomena in these forms of pluralism because there are infinite ways to classify the world. Moreover, we are unable to distinguish which ones are correct. Kellert et al. (2006, xiii) think that these radical pluralisms are reducing to relativism. Kellert et al. (2006, xiii-xv*)* position their pluralist stance between modest and radical interpretations, defining their interpretation as "empirically based." They claim that their position "is not based on metaphysical assumptions" (Kellert et al. 2006, xiii) because it is epistemological, that is, "the only way to determine whether a part of the world will require a plurality of accounts is to examine the empirical results of scientific research of that part of the world" (Kellert et al. 2006, xxiii).

In her doctoral dissertation, Sophie Juliane Veigl (2020, 226) criticizes Kellert et al.'s Modest-Radical classification as inadequate, arguing that it cannot distinguish between pluralist positions. Then, she proposes four alternative classificatory schemes to distinguish between different pluralisms. She conceives of these four separate dimensions as spectrums, where different pluralist philosophers occupy relative positions to one another. Veigl (2020) extensively addressed these classification schemes in her dissertation, specifically in the "Classification Revisited" subsection between pages 233 and 246. These four dimensions are as follows:

1) The Neurathian – Feyerabendian dimension
2) Realism – Anti-Realism Dimension
3) Theory Choice Dimension (Science – Pseudo-Science)
4) Integration - Non-integration Dimension

The last of the four dimensions, the integration-non-integration Dimension, is relevant to my thesis, so I will discuss it in detail.

According to Veigl (2020, 244-6), the fourth dimension of pluralist diversity is how "different theories relate to each other." She refers to this dimension as the "Integration-Non-Integration Dimension." Below is an adaptation of Figure 25 of Veigl (2020, 245). You can see the relative positions of pluralist philosophers of science on the "Integration-Non-integration Dimension."

Figure 1. The relative positions of pluralist philosophers of science. Veigl states they are on a spectrum from the Integration to the Non-integration Dimension. The figure is a reproduction of Figure 25 of Veigl (2020, 245).

Veigl's (2020, 246) description of the philosophical landscape is below:

> Integration is central to Mitchell's position. Integration is also very prominent in Chang's position for its epistemological benefits. Galison,

> Cartwright, and Neurath have different takes on the integrability of approaches. Although they deny that integration is possible in principle, they believe in integrating different strands of research in local and contingent settings. The other end of the scale is inhabited by those pluralists who discourage integration. The Pluralist Stance is most explicit in rejecting integration as a goal of pluralism. In Feyerabend's and Hacking's accounts, integration is not explicitly discouraged but seems not feasible. Dupré, too, emphasizes the purpose and sensitivity of approaches; integration is not a goal that fits his agenda. Suppes, finally, does not consider the possibility of integration.

In my thesis, I further utilized Sandra D. Mitchell's integrative pluralism to examine the MS-EES debate. Mitchell's integrative pluralism is tailored to study complex phenomena, primarily biological and social complexities. Most of her case studies are about evolutionary phenomena, some even about the early precursors of the MS-EES debate, making it a good fit for my objectives.

CHAPTER 4

INTEGRATIVE PLURALISM

In the previous chapter, I mentioned the plurality of sciences and briefly mentioned the diverse ways of embracing this plurality, namely pluralism. I also mentioned that I have chosen integrative pluralism, among many kinds of pluralisms, to examine the EES debate. In this chapter, I described integrative pluralism. My account of integrative pluralism is based on Sandra D. Mitchell's integrative pluralism, which, I believe, is the most sophisticated and sustained defense of integrative pluralism over the years. I will summarize Mitchell's book-length argument in detail in this chapter. First, I briefly address the concept of complexity and portray the complex nature of biological phenomena. Second, I elaborate on the consequences of complexity in biological phenomena, which lead to integrative pluralism. Third, I summarize Mitchell's understanding of integrative pluralism. In the next chapter, I will apply my understanding of Mitchell's integrative pluralism, as presented in this chapter, to the MS-EES debate.

4.1. Mitchell's Argument for Integrative Pluralism

Mitchell's argument for integrative pluralism has two foundations. The first foundation is ontological, and the second is epistemological. The ontological claim implies the epistemological claim. These two claims are based on complexity. The argument is as follows: ontologically, sciences like biology and psychology engage with complex phenomena, and traditional scientific epistemology is ineffective in dealing with the complex natures of these phenomena. Epistemologically, the biological and psychological sciences must reflect on this complexity to achieve success. From these premises, Mitchell concludes that it is necessary to find a new way of doing science, which, according to her, is integrative pluralism.

4.1.1. Biological Complexity

Complexity can be found everywhere in nature, from the microscopic to the cosmological scale. The struggle against complexity was apparent in attempts to understand the world from the beginning of science. The strategy to make the world's phenomena more understandable was to simplify it by reduction. With the advent of modern science, this strategy paid well, as in the case of the Copernican Revolution, which reached its apex with Isaac Newton's three laws, which can explain the complex motions of heavenly bodies (Mitchell 2012, 1).

Mitchell (2012, 11) refers to three 19th-century philosophers of science— John Herschel, William Whewell, and John Stuart Mill —who were impressed by the success of the 17th-century Scientific Revolution, particularly Newton and his laws of physics. All these philosophers of science "attempted to capture the essence of 'the scientific method' attributed to Newton," which is an almost "algorithmic procedure for revealing the simplicity underlying the complexity..." (Mitchell 2012, 11).

Mitchell quotes William James's description of the complexity of the world as "blooming, buzzing confusion" (James 1890, 462 in Mitchell 2012, 11) and the traditional scientific attitude of reducing this complexity "to simple, universal, and timeless underlying laws to explain" (Mitchell 2012, 11).

For 19th-century philosophers of science, induction from empirical facts provides us with "reliable knowledge" that is universal, deterministic, simple, and unified. However, during the quantum revolution in physics at the beginning of the 20th Century, these great expectations from science were curbed but not wholly abandoned. Further into the twentieth century, developments in biological sciences that introduced "the historical and contingent complexities" of nature advanced the criticism of the "traditional views of scientific knowledge" (Mitchell 2012, 12).

New scientific developments in the twentieth century revealed new complexities that do not easily lend themselves to the usual ways of doing science that have been in scientists' repertoire for centuries. Mitchell provides several examples of phenomena that harbor these kinds of complexities, which are "resistant to the traditional strategies," such as man-made climate change, the development of an organism from a zygote to a fully grown individual, and the internal workings of a honeybee colony (Mitchell 2012, 2).

According to Mitchell, one of the reasons traditional ways of doing science do not work on these phenomena is that they do not fall within the domain of physics, where reductive strategies are exceptionally effective. The benefits of reductive strategies are limited in both biological and social sciences. Therefore, Mitchell suggests that "new approaches to knowledge and action are required to understand and manage the complexity of nature." Furthermore, she asserts that these new approaches to science are prevalent in contemporary scientific practice. Her philosophical view, which she calls integrative pluralism, can be used to ground a new epistemology of science that "embraces both traditional reductive and new, multilevel, context-dependent approaches to scientific explanation and prediction" (Mitchell 2012, 2).

Mitchell argues that life in the biological sense is "not simple"; therefore, our theories, explanations, and representations of it "will not be simple either." According to her, it is possible to understand the complexities of nature, but this requires "new ways of understanding." These new ways of understanding, which expand the traditional epistemology of science, need several new features. Namely, pluralism, pragmatism, and an understanding that knowledge is "dynamic and evolving" (2012, 13).

To show the unsettledness of the definition of complexity, physicist Seth Lloyd, who frequently gets quoted, lists at least 45 definitions or measures of complexity (Horgan 2015). Mitchell also refers to John Horgan, with the same objective of underlining the lack of an agreed-upon definition of complexity, in her *Biological Complexity and Integrative Pluralism* (2003, p. 4). Mitchell's strategy to overcome this difficulty is to limit her account of complexity to biological complexity. She avoids giving another definition of complexity and directly continues with a taxonomy of biological complexity. In *Biological Complexity and Integrative Pluralism* (2003), she gives three categories of complexity in the biological domain: compositional complexity, evolved complexity, and dynamic complexity. In her more recent book *Unsimple Truths: Science, Complexity, and Policy* (2012, 21), she mentions four categories of biological complexity: "multilevel organization, multicomponent causal interactions, plasticity in relation to context variation, and evolved contingency." These two different taxonomies of complexity overlap mostly, and I used both in my account of biological complexity below.

Constitutive (or compositional) complexity is the most straightforward type of complexity in biological systems. Any complex system, such as an organism or an ecosystem, differs from simple things in that it is composed of many parts that interact with each other in various ways within a structure (Mitchell 2003, 4-5). Several characteristics of constitutively complex systems make them more challenging to study, represent, and understand using traditional scientific methods, which are inherently reductive in nature.

First, a complex system, such as an ecosystem, can be built by a different set of components without affecting the system's functions. For example, in an ecosystem, a species occupying a specific niche can be replaced by another species without significantly affecting the ecosystem's overall functioning (Mitchell 2003, 5).

Another well-known characteristic of complex systems is that they have hierarchically organized levels. An external effect acting on an organism may affect the whole organism or some parts in one of the lower levels, and the organism's reaction depends on its constitution. The organism's reaction to the external effect may be limited to the affected level of organization, such as the cellular level, or, through some chain reactions, expand to the whole organism level (Mitchell 2012, 21).

A system's architecture is also essential in studying it. It can be built in various ways, "from simple aggregation to dynamic feedback structures" (Mitchell 2012, 21). Naturally, differently constructed systems require different approaches to studying and representing them.

To sum it up, complex systems defy "the traditional reductive strategies of decomposition and analysis 'reduce' a complex system to its parts and study the component structures in isolation to understand the behavior of the whole" (Mitchell 2012, 21).

Dynamic complexity in biology may be best exemplified by the developmental process of multicellular organisms from a single-celled zygote to a grown adult or the whole evolutionary process that took billions of years from the first cells at the origin of life on Earth to today's complex tree of life that consists of billions of different species (Mitchell 2003, 5).

Evolved complexity is the third kind of complexity found in the biological realm. That is the vast diversity of forms organisms exhibit in response to the struggles encountered in their life (Mitchell 2003, 5). Explaining the diversity observed in the biological world is one of the primary objectives of the biological sciences, and the solution found to address this problem is evolution. Historicity and contingency are integral to the irreversible process of evolution, which is a biological system's way of solving "the problems of survival and reproduction," which turn out to be quite creative as similar problems encountered by different organisms are solved in diverse ways depending on their history and variability (Mitchell 2003, 7). It is a mundane fact of the biological world that different organisms "display varied, alternative adaptive solutions to similar selective regimes, and the same adaptation may be reached by very different means" (Mitchell 2012, 45).

After examining the different varieties of biological complexity, I will briefly summarize how these complexities interact within a system. Complex systems, in our case, biological systems, are composed of multiple structured or ordered parts beyond simple aggregation. These parts relate to each other in different ways within the ordered structure. The interactions among these parts within the system are not static but context-sensitive, which means they are subject to change depending on internal or external circumstances. Furthermore, these features of complex biological systems enable them to evolve, allowing the constitutions of their parts and their functions to change or adapt better to changes in their context, over deep time and across generations. These changes are also contingent, which means they could be otherwise, albeit within limits. For concrete examples of complex systems, let us consider two complex biological systems: an organism and an ecosystem. Any multicellular organism consists of various systems. Every system an organism has consists of organs, which are composed of different tissues, tissues are composed of cell clusters, and cells are composed of various kinds of non-living macromolecules. On the other hand, an ecosystem comprising living and non-living parts is less tightly structured and organized, albeit temporarily and spatially vast, and more durable than an organism. However, it is still a complex system made of elements, an extensive and diverse number of organisms from bacteria to apes and trees, and the niches they occupy all interact in an incredible variety of ways.

4.1.2. Features of Biological Complexity Require Integrative Pluralism

The concepts of emergence, reduction, scientific laws, and causality are closely related to biological complexity. Although emergence is a metaphysical concept and reduction is an epistemological concept, Mitchell puts them in "direct opposition" (2012, 24). Mitchell's argument pursues the following reasoning: The biological complexity leads to the emergent properties of living things, which substantially impedes the efforts to understand life through reduction (Mitchell 2012).

Mitchell (2012, 24) traces the history of the concept of emergence back to Aristotle, citing a famous remark attributed to him: "The whole is more than the sum of its parts." She notes that there are conceptions of emergence in the history of the idea that are "antithetical to physicalism or materialism" by their assumptions that "posit a wholly different and unique substance above and beyond the physical" (Mitchell 2012, 24). Mitchell draws a clear line between these conceptions of emergence and those meaningful for science, which accepts only one kind of substance: material substance. She agrees with materialist/physicalist monism, which has provided a firm ground for science since the seventeenth century (Mitchell 2012, 24).

According to Mitchell (2012, 24), there are possible ways to reconcile emergence and modern science, which go through the denial of the reduction to a degree:

> There are interpretations of emergence that do not conflict with materialism, yet deny the sufficiency of a simple reductive strategy for scientific explanation. These are the only accounts that are meaningful to consider in understanding the complexity studied by the modern sciences.

A weak denial of reductionism is key to Mitchell's argument for integrative pluralism. She does not think reduction is impossible in all cases. On the contrary, her point is that reductionism, which assumes that "all compositionally complex structures and systems can be explained, without remainder, by appeal only to the properties of their simplest components," is not always sustainable (Mitchell 2012, 24).

I will return to reduction later in this chapter; now, I should extend Mitchell's understanding of emergence, which takes its roots in the 1970s complexity science, which investigates "chemical and neurological complexity" that needed a scientific account for emergence (Mitchell 2012, 25).

As I pointed out earlier, scientific emergence presupposes only one kind of substance—matter. This substance builds the lower-level components of complex structures and their higher-level emergent and non-emergent properties (Mitchell 2012, 26).

An advanced conceptual framework is needed to make sense of scientific emergence, incorporating new concepts and some of the older conceptualizations from previous centuries. The new understanding of scientific emergence shares with older conceptions of emergence the idea that the whole possesses novel properties due to the interaction among the parts that none of the components possess individually. However, scientific emergence has conceptual tools that help make sense of this emergent property, unlike the older accounts of emergence (Mitchell 2012, 36).

One of these new conceptualizations regarding emergence is "self-organization," which explains how complex systems are structured and organized (Mitchell 2012, 36). It "is grounded in multiple forward and reverse feedback loops that can be radically sensitive to initial and evolving boundary conditions" (Mitchell 2012, 36).

Scientific emergence explains the emergent properties of complex systems through interactions among component parts. However, these interactions are non-aggregative and chaotic and harbor feedback mechanisms. This causes the emergent properties of higher levels to be unpredictable from the intrinsic properties of the lower-level parts. Furthermore, higher-level properties can influence the behavior of lower-level parts, a phenomenon known as downward causation (Mitchell 2012, 44).

However, it is essential to note that not all higher-level properties are emergent; some are simple and can be explained by reductive strategies. This is one of the features of the "integrative pluralistic ontology and epistemology" (Mitchell 2012, 44).

Reduction is another crucial concept in understanding the necessity of integrative pluralism in studying complex biological systems. There are many versions of reductionism, but all forms of reductionism agree that the behavior of a system should be explained by the behavior of its lower or lowest-level components. According to Mitchell, this approach cannot account for many features of complex systems. After making this point, Mitchell resists the other extreme end of full-fledged anti-reductionism. Instead, she notes that reductionism is not the wrong strategy, but rather "an incomplete one" (Mitchell 2012, 22).

Mitchell points out both the reasonable and troublesome aspects of reductionism. It is reasonable to think that since everything is composed of one kind of substance, namely matter, complex systems are also composed of matter. She refers to this as the "material composition assumption" (Mitchell 2012, 23). However, Mitchell notes two problematic points made by reductionism. The first is reductionism's claim that all representations should be reduced to the privileged fundamental level of matter. Mitchell argues that this claim fails because it misses the fact that all representations are partial in essence (Mitchell 2012, 23).

> Any representation—be it linguistic, logical, mathematical, visual, or physical—stands for something else. To be useful, it cannot include every feature in all the glorious detail of the original, or it is just another full-blown instance of the item it represents. Something must be left out, and what is left out is a joint product of the nature of the representing medium (Perini 2005) and the pragmatic purposes the representation serves. (Mitchell, 2012, 31)

This means that two different representations of the same phenomenon can be incompatible due to conflicting pragmatic purposes and representation mediums (Mitchell 2012, 31).

The second problematic claim of reductionism is that all causations are based on a bottom-up understanding of compositional assumptions, which overlooks other features of complex systems, such as feedback mechanisms, that lead to downward causation. Mitchell (2012, p. 24) summarizes that "understanding both the nature of representations and the complexity of causal dynamics precludes a simple-minded reductionism." Evolved complexity challenges one of the traditional ways of doing science: explaining observed complexity with simple natural laws. The complex diversity of the biological world resists the explanation of biological phenomena by appealing to simple laws of nature. The lack of laws in biology, similar to the laws of physics, is due to the evolved nature of the biological world, which renders it "more contingent and less universal, more ephemeral, less fundamental, and hence subject to change under a variety of contextual scenarios" (Mitchell 2012, 49). In short, lawlessness in biology is another consequence of the complexity observed in the biological world, which hinders the study of it with the traditional reductive scientific attitude.

Causal inferences are another indispensable part of traditional scientific epistemology that is not well-suited to the complexity of biological phenomena. Mitchell examines "Mill's Method" as the clearest example of causal inference. According to Mill's method, causal inference can be made by observing two systems that are exact replicas of each other, except for one factor. When these two systems are examined, the observed difference between them can be attributed to the only differing factor (Mitchell 2012, 67). However, due to their complex structures, systems pose significant challenges to Mill's Method, particularly with their feedback loops and contingent natures (Mitchell 2012, 84). Mitchell (2012, p. 84) concludes that the philosophy of science should rethink "what counts as a cause and the logic of causal inference" to accommodate the new understanding of complex systems (Mitchell 2012, 84).

4.1.3. A Way Forward

Our world is complex. This complexity does not, in most cases, lend itself to simplistic methods of investigation and inference. Truths about our world are seldom "simple, global, and necessary" (Mitchell 2012, 105). Our understanding of how nature works needs to change. We should abandon the notion that nature is furnished with "regularities and causal powers that are universal, deterministic, and predictable" (Mitchell 2012, 105).

Mitchell promotes integrative pluralism as an expanded scientific epistemology that does not propose abandoning traditional scientific epistemology, but rather extending it in response to what has been discovered through studying the complex world around us (Mitchell 2012, 105).

4.2. Integrative Pluralism

Mitchell's integrative pluralism justifies itself on the basis of the complexity and contingency of biological and social phenomena. Mitchell claims that complex phenomena resist reduction due to their emergent properties and lack of all-encompassing laws. Reduction is the traditional way of explaining natural phenomena in science, which has worked remarkably for centuries since the Scientific Revolution. However, this way of doing science reached its limits during the early twentieth century, first in physics and then in other domains as these sciences advanced. Contrary to what Kuhn (2012) suggests, as these sciences matured, their plurality did not decrease but increased. Especially in biological and social sciences, the traditional way of doing science is insufficient to explain most phenomena.

By studying the sciences of complex phenomena from different domains, Mitchell concludes that "only nonreductive, *integrated* multilevel, pragmatically targeted explanations will succeed" in explaining many complex phenomena. She refers to this approach as integrative pluralism (Mitchell 2012, 106).

Mitchell's (2012, 109) integrative pluralism has several features as an expanded epistemology of science. First, it suggests that explanations should be multilevel and integrated. Second, pragmatism replaces the absolutism of the traditional scientific epistemological standards of truth (Mitchell 2012, 15). Third, integrative pluralism recognizes that the static universalism of traditional scientific epistemology should be replaced with a dynamic and evolving understanding of knowledge (Mitchell 2012, 16).

4.2.1. Integrated Multilevel Explanation

Traditional reductionist scientific epistemology aspires to explain the behavior of a complex system by finding the single structural cause that is effective in all contexts. However, this is not the case with complex systems with emergent properties. A higher-level emergent property arises from the interactions among the lower-level components of a system. Both internal and external factors influence these lower-level components, and furthermore, they can also interact with the higher-level emergent properties. Therefore, reductionist attempts to explain the behavior of a complex system through "only the most basic properties of the most basic entities" will miss many important higher-level components and their effects on that system and the system's behavior (Mitchell 2012, 109).

As mentioned above, both the ontology and the evolutionary history of a complex biological system require pluralism of explanations. The relationship among these multiple explanations may differ. Different explanations of the same aspect of a phenomenon can compete, or they may be compatible explanations of different aspects of the same phenomenon. Furthermore, multiple explanations of the same phenomenon may even be complementary (Mitchell 2012, 109-10).

There are three different relationships between multiple explanations of the same phenomenon. The first one is, as the name suggests, competitive pluralism. The second and third can both be described as compatible pluralism. However, if this compatibility does not include interactions between compatible explanations, it is referred to as a "levels-of-analysis" approach. If these compatible explanations are also complementary to each other, it is called integrative pluralism.

At this point, the question of how this complementarity works arises: How does integrative pluralism integration happen? Due to the multiplicity of components and their interaction, it is impossible to devise an algorithmic integration method (Mitchell 2012, 114). Mitchell (2012, 110) clearly indicates this several times in her book; in one instance, she states: "Pluralism in causes, pluralism in ontological levels, and pluralism in integrations will characterize the scientific explanation of complex system behavior." This means an integrative explanation for every phenomenon under investigation should be constructed anew. Even closely related phenomena might require a slightly different explanation due to the multiplicity of factors interacting and their context sensitivity (Mitchell 2012, 114).

4.2.2. Pragmatic Nature of Integration

With the rejection of a privileged-level explanation due to the rejection of the reduction through unification, it is no longer possible to determine an absolute standard for the rejection or acceptance of explanations and representation in advance. Therefore, our decisions on whether to accept or reject a representation will be based on our aims and interests. This also means that different aims and interests can lead to equally legitimate multiple representations of a phenomenon under investigation (Mitchell 2012, 15). Mitchell (2012, 13) puts this succinctly:

> Pragmatism in place of absolutism, which recognizes there are many ways to accurately, if partially, represent the nature of nature, including various degrees of generality and levels of abstraction. Which

> representation "works" best is dependent, in part, on our interests and abilities.

4.2.3. Dynamic Perspectives

Integrative pluralism's third and final feature is the "recognition of the dynamic and evolving character of knowledge replaces an expectation of static universalism" (Mitchell 2012, 16). The sciences of complex systems teach us that their structure defies the completely deterministic, predictable understanding of these systems that was envisioned by Laplace. There are two options before us. The first is falling into despair by following the traditional scientific epistemology. The second involves recognizing failures and abandoning the unrealistic expectations of traditional scientific epistemology, embracing instead the plurality and constantly changing nature of knowledge (Mitchell 2012, 117). Mitchell (2012, p. 119) offers integrative pluralism as a step toward an "expanded understanding of our complex world," where traditional scientific epistemology proves inadequate.

In this chapter, I have briefly explained Sandra D. Mitchell's integrative pluralism, which, according to her, is an expanded scientific epistemology for complex biological phenomena. Although my thesis solely depends on Mitchell's version of integrative pluralism, hers is not the only version. Muszynski and Malaterre (2021, 1785) list a number of publications that deal with the concept of integration and pluralism, such as Darden and Maull (1977), Kitcher (1981), Brigandt (2013), Leonelli (2013), O'Malley (2013), Hochstein (2017), Sullivan (2017), and Laubichler, Prohaska, and Stadler (2018). However, Muszynski and Malaterre (2021, 1785) also note the following about integration:

> One recurring yet often poorly defined concept in debates regarding pluralism is the notion of 'integration.' This is roughly the idea that explanations can, in one way or another, merge to provide a more

> complete or more apt explanation of a phenomenon. Though many seem to agree that integration is valuable, little has been said to justify its value, nor to describe precisely what integration amounts to, despite the fact that many (sometimes piecemeal) accounts exist [.]

However, I do not agree with the above quote, which asks for a precise description of integration. Mitchell (2003, p. 194) already demonstrates that integration cannot be algorithmic and cannot be precisely described due to its complex nature. Instead, I tend to see integration much like bricolage, an art form that requires bringing different things together creatively to create a new whole where parts loosely hang together.

Another aspect of integration that should be addressed is its relationship with unification. First, there is no clear distinction between integration and unification. Different authors use these words interchangeably, often using one to mean the other. It is better to think that there is an intersection between them where differentiation occurs gradually, in a spectrum. In this spectrum, integration represents a middle ground between unificationism and isolationist pluralism. Still, I believe that extreme forms of unification can be easily differentiated from integration. While unification requires reduction, uniformity, and all-inclusiveness, isolationist pluralism is against all of these, and integration sits in the middle, enjoying the best of two worlds. Lastly, we can try to locate the MS and EES in this spectrum of integration and unification. While modern synthesis is closer to the unificationist end of the spectrum, EES is more pluralistic due to its still-forming and incoherent structure, yet it remains closer to the unificationist end than the integrative middle. Probably too close to sit comfortably without falling into the unificationist singularity.

In the following chapter, I will apply Mitchell's strategy to the most complex biological phenomenon known: evolution. I will also attempt to examine the

Modern Synthesis versus Extended Evolutionary Synthesis debate from the perspective of integrative evolutionary pluralism.

CHAPTER 5

INTEGRATIVE PLURALISM FOR EVOLUTIONARY THEORY

In this chapter, I will first present a selective, critical examination of EES through the publications I consider milestones in the MS-EES debate, and I will also refer to some publications that I believe support my position in this debate, namely the integrative evolutionary pluralism (IEP) which is a third but not a middle way between MS and EES. To my understanding, both the MS and EES exhibit unificationist tendencies, although EES's unificationism is less prominent than that of the MS. Nevertheless, I believe it is still present. Both MS and EES claim to provide or aspire to provide an all-encompassing theoretical framework that explains or applies to all evolutionary phenomena. I am hoping that I have already shown the impracticality and improbability of this aspiration due to the complexity and diversity of the evolutionary phenomena.

Instead, I will advocate for abandoning the search for a comprehensive theory of evolution, which is all-encompassing and all-explaining, and approach the issue at hand with a pluralist stance. Sandra D. Mitchell's integrative pluralism has a significant influence on my own pluralism. However, I disagree with her that there should be a single, integrated explanation for every phenomenon. As we will see, I believe that the aims of a researcher or research program determine the final outcome of an integrated explanation, and different aims yield different results. My pluralist understanding is that we should embrace the plurality and diversity of evolutionary theories, approaching them as tools in our evolutionary toolbox to reach integrative explanations of evolutionary phenomena. Abandoning the aspiration for comprehensive evolutionary theory and focusing instead on explaining singular evolutionary phenomena is what I suggest, which I call integrative evolutionary pluralism (IEP). The motto of IEP is the following:

The point of integration is not the theory but the explanation of the phenomenon.

This clearly separates IEP's integration from other kinds of integrations, which may be unificationism in disguise.

5.1. A Critical Examination of the Extended Evolutionary Synthesis

Modern synthesis has been the most successful and dominant way of understanding evolution since the early twentieth century. Although it is widely accepted, there has been dissatisfaction with it almost from the beginning.

Motoo Kimura's Neutral Theory and Stephen Jay Gould's and Niels Eldredge's Punctuated Equilibrium were two major dissenting proposals from the MS orthodoxy in the second half of the twentieth century. The neutral theory was successfully reduced into the MS framework (Futuyma, 2023), and Punctuated Equilibrium was mainly deemed redundant (Futuyma, 2015).

In the first decade of the new millennium, another dissenting view from MS started to take off: the Extended Evolutionary Synthesis (EES). EES' criticism was similar and rooted in earlier criticism from the 1980s; however, its supporters are diverse, numerous, and better organized. After almost 20 years, EES seems to be here to stay, yet it is still marginal. EES's primary strategy is to accept the MS framework but extend this framework, as the name suggests, by inclusion of the excluded disciplines and phenomena from the MS framework.[4]

Although hundreds of publications concerning the MS-EES debate have been published since EES's inception, a handful of milestone articles and books must be addressed. Below is a treatment of these milestone publications. Although there had been some dissenting articles before, 2007 marked the first occurrence of the term "Extended Evolutionary Synthesis," as introduced in an article by Massimo Pigliucci titled "Do We Need an Extended Evolutionary Synthesis?" In this article, Pigliucci declared the major goal of EES as "a unification of our theories of genes and of forms" (Pigliucci 2007, 2743). Pigliucci refers to previous incarnations of evolutionary theorizing of explaining how this unification might have happened:

> What I think will happen over the next several years is a process analogous to the MS itself: not a paradigm shift a la Kuhn (1970), but another series of complex developments that build on its three major predecessors: Darwinism, neo-Darwinism, and the MS itself. (Pigliucci, 2007, 2748)

The same year, Gerd B. Müller (2007) published an article titled "Evo–Devo: Extending the Evolutionary Synthesis." With this article, Müller (2007, 943) aims to identify "major theoretical themes of current evo–devo research and highlights how its results take evolutionary theory beyond the boundaries of the Modern Synthesis." Müller's article is more focused on evo-devo and spends a lot of ink on different aspects of evo-devo that can expand the

[4] I need to note that EES supporters are a group of diverse people, with everyone having their voice; therefore, it is hard to specify a unified stance on many issues among them. What EES is trying to achieve is one of the points of discussion among EES advocates; there are both mild revisionists and revolutionaries among them (Lala 2019).

evolutionary framework. Another theme of this article was the differences between MS, which is equated with population genetics, and evo-devo, and how evo-devo will affect MS.

> The theoretical framework of the modern synthesis rests on a population genetics core that describes how the relationships between genetic variation, heredity and reproduction affect population dynamics. By contrast, evo–devo theory establishes how the relationships between genes, cells and developmental interactions affect the evolution of phenotypes. Hence, evo–devo does not invalidate the formal framework of the Modern Synthesis, but adds another level of explanation. The reach of evolutionary theory is expanded in that evo–devo accounts not for what kinds of variation are going to be maintained through natural selection, but also what kinds of variation can possibly arise from specific developmental systems. (Müller 2007, 947)

Notice that both Pigliucci (2007) and Müller (2007) make modest claims. They both avoid claims of paradigm shifts or extensive theoretical overhauling. Three years later, Pigliucci and Müller (2010b) published a jointly edited book, *Evolution—the Extended Synthesis*. In this volume, diverse voices are represented from different disciplines and with differing stances towards EES. There were also two philosophers, Alan Love and Werner Callebaut, whom I have already mentioned in the previous chapters. Pigliucci and Müller co-authored the book's introduction, in which a figure represented different stages of evolutionary theory through concentric sets. The central set, comprising three elements, represents the core of the evolutionary theory developed by Charles Darwin. The second set, with five more elements, describes MS. The third (outer) set, with eight more elements, represents the EES theory of evolution. Every member of these three sets represents elements of evolutionary theory. As the figure shows, EES advocates are extending the modern synthesis by adding new theories and phenomena to evolutionary theory.

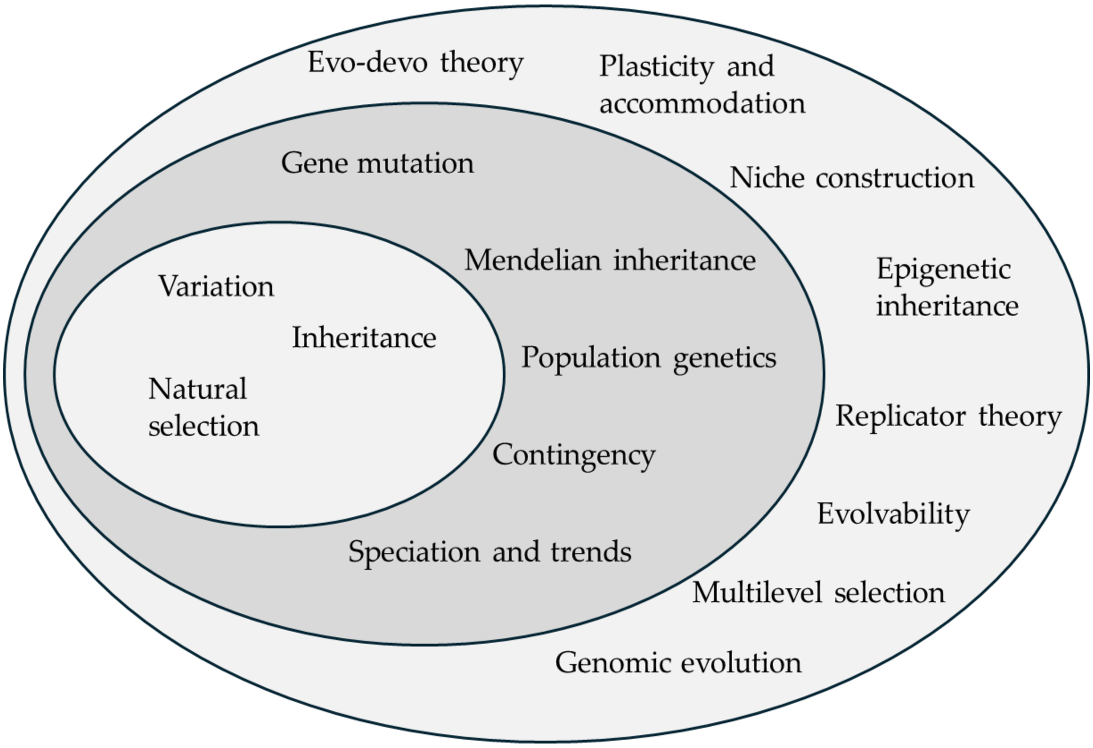

Figure 2. Schematic representation of key concepts. The center set represents the Darwinian core, the middle set represents Modern Synthesis, and the outermost set represents the proposed Extended Evolutionary Synthesis. The figure is adapted from Pigliucci & Müller (2010a, 11) Figure 1.1.

In this book, Pigliucci and Müller (2010a, 12) assure us that, after the EES, "the general principles of the population-dynamical core of the classical theory" will not be compromised because the new expansions were not about population genetics. However, they also announce that the explanatory power of the evolutionary theory will be significantly expanded with EES. Furthermore, they also claim that, somewhat contradictorily with the above assurance. "The extended framework overcomes several basic restrictions and methodological commitments that had been necessary for the correlational approach of the MS to work" (Pigliucci and Müller 2010a, 13). Pigliucci and Müller (2010a, 13) count three such restrictions that EES will overcome. These are gradualism, externalism, and gene centrism, which are collectively summed up as a drastic change within the theory of evolution.

In 2014, a very unusual article was published in Nature. The title asked, "Does evolutionary theory need a rethink?" In this four-page article, the most prominent evolutionists gave two diametrically opposite answers to this question. In Kevin Laland et al. (2014, 161) the proponents of EES said, "Yes, urgently," the opposing side answered, "No, all is well."

The opposing side explained their answer with the typical utterance of the basic tenets of MS.

> All four phenomena that Laland and colleagues promote are 'addons' to the basic processes that produce evolutionary change: natural selection, drift, mutation, recombination and gene flow. (Laland et al. 2014, 164)

On the other hand, the part of the article that is allocated to proponents of EES tried to convince the audience that:

> The above insights derive from different fields, but fit together with surprising coherence. They show that variation is not random, that there is more to inheritance than genes, and that there are multiple routes to the fit between organisms and environments. Importantly, they demonstrate that development is a direct cause of why and how adaptation and speciation occur, and of the rates and patterns of evolutionary change. (Laland et al. 2014, 164)

And they add:

> We believe that a plurality of perspectives in science encourages development of alternative hypotheses, and stimulates empirical work. No longer a protest movement, the EES is now a credible framework inspiring useful work by bringing diverse researchers under one theoretical roof to effect conceptual change in evolutionary biology. (Laland et al. 2014, 164)

Laland et al.'s (2014, 164) section is critical for my thesis because it mentions the "plurality of perspectives," the different scientific fields that "fit together with surprising coherence," and "one theoretical roof." I see these seemingly contradictory phrases as a sign of EES proponents' aspiration to one coherent theoretical framework, namely the extended synthesis, which I believe is a project of unification.

On the other hand, Gerd B. Müller's (2017, 9) article is clearly pluralistic and aspiring to integration:

> Instead of privileging selected mechanisms such as random variation, genetic control and natural selection, the multitude of factors that dynamically interact in the evolutionary process will be better expounded by a pluralistic theory framework. Current evolutionary research already reflects this pluralism, and as many of its underlying concepts have drifted from the standard theoretical paradigm, an adjusted evolutionary framework that adequately synthesizes the multitude of new theoretical elements has become a necessity. The EES represents one possibility for such integration.

In the concluding report of an EES project, Lynn Chiu (2022) introduces a new representation of the extension process in evolutionary biology, presented as a Tangram puzzle in Figure 29 on page 57 of this report (Figure 3, here). An extension to a Tangram puzzle represents a similar idea of evolution from MS to EES. This representation is more sophisticated than the co-centric sets as it describes different stages of the expansion of the theory, the restructuring of the puzzle, and the addition of new pieces/theories. During the expansion, a transition period of non-coherence is observed as a midway stage. This representation also advocates for a single, coherent theoretical structure, which is not very different from MS.

Also, the EES Project's website has a subtitle that says, "An integrative research program" under its logo (Extended Evolutionary Synthesis—*An Integrative Research Program*, n.d.).

The major milestones in the MS-EES debate are listed above. Hundreds of other publications exist with a wide range of opinions. However, before concluding this discussion, I would like to mention several additional articles related to the MS-EES debate.

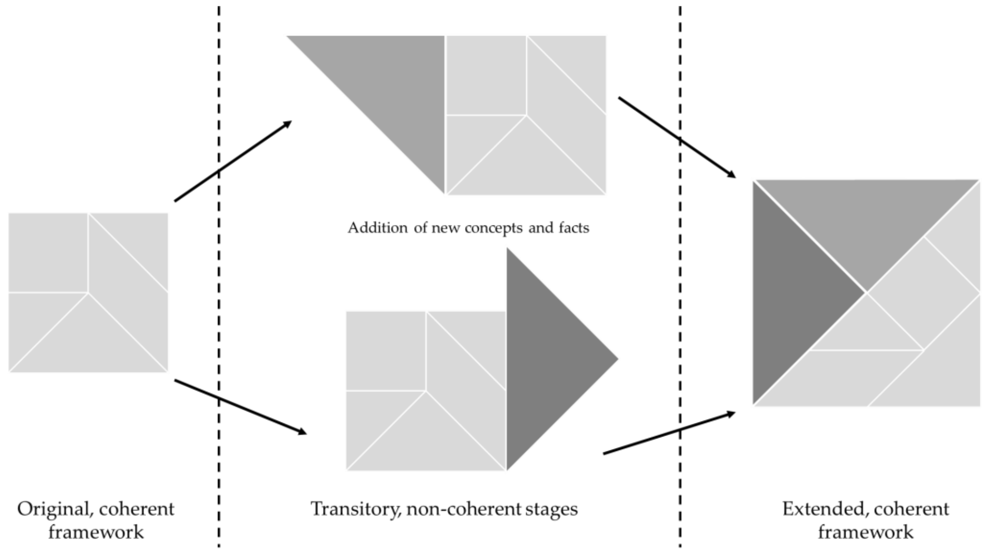

Figure 3. Tangram puzzle analogy to illustrate achieving a new synthesis in evolutionary biology (i.e., EES). The figure is a reproduction of Figure 29 by Lynn Chiu (2022, 57).

The first one belongs to Arlin Stoltzfus (2017), titled "Why We Don't Want Another 'Synthesis'" Stoltzfus (2017, 6) concluded his article with the following passage:

> Today, wishy-washy defenses of an ongoing "Synthesis" are easy targets for a badly needed reform in our ongoing discourse on the state of evolutionary thought: rejecting Synthesis propaganda, and accepting evolutionary biology as a legitimate scientific discipline that entertains bold conjectures about the measurable effects of novel causes, with no need for a master theory. The era of master theories based on ruling principles and grand schemes is long past. The OMS [Original Modern Synthesis] was the last such theory. There will not be another.

According to Stoltzfus (2017), who is well-versed in the history of evolutionary theory, MS is a "moving target," following the lead of Smocovitis' historical narrative, not a "fixed theory." He refers to the MS crafted between 1930 and 1940 as the original modern synthesis (OMS), which failed in the 1960s due to the advancement of comparative sequencing technology (Stoltzfus 2017, 3).

However, it continues to influence due to the persistence of this historical narrative (Stoltzfus 2017, 4). Stoltzfus (2017, 6) recommends that we should abandon this view of evolution and our desire for a grand theory of evolution and instead gravitate towards a plurality of evolutionary modes:

> "Separating the totality of evolutionary change into different aspects or modes, each of which follows distinct rules and implicates causal factors differently, is a valuable goal for evolutionary theorizing." (Stoltzfus 2017, 6)

I agree, and I will recommend a very similar idea below. But before I do, I need to clarify two things.

The first is the difference between evolutionary plurality and evolutionary pluralism, and the second is the different uses of the word "integration." It should be obvious that there is a plurality of evolutionary theories, processes, mechanisms, and so on if one is not blinded by ultra-Darwinism. However, what makes one a pluralist is embracing this plurality. Although many supporters of EES, including some supporters of the MS, accept the plurality, they typically attempt to overcome this plurality through synthesis, integration, or unification as their ultimate goal.

This is exactly why Reis and Araújo (2020) object to the use of the words "extension" and "synthesis" in naming EES. First, the proposed changes in theory structure are much more extensive to call it merely an "extension." Second, it should not be named a "synthesis", which is a much more conservative term than the intended plurality of EES, at least for the short to medium term. They conclude that:

> We believe that adhering to the extended evolutionary synthesis has as a consequence the legitimation of a plurality of approaches (not yet synthesized and even difficult to be synthesized in the short term) and a transformation of evolutionary synthesis (as opposed to a mere extension). (Reis and Araújo 2020, 60)

Another article by the same authors argues against the unificationist ideal of MS and supports a kind of integrative evolutionary pluralism:

> "In this way, when we look at scientific practice we do not find a broad synthesis in biology, but rather a series of integrations that do not involve a stable unification of different fields of biology. These forms of integration may be compatible with a pluralistic stance, without recourse to more traditional visions of the unity of science. Unification is not a goal in itself from the viewpoint of evolutionary pluralism, but local integrations occur and should occur in biology for specific epistemic purposes. Our criticism addresses the alleged broad unification of biology as a whole via biological evolution." (Araújo and Reis 2021, 16)

Once again, I agree. Below is what I am advocating for, a kind of integrative evolutionary pluralism (IEP), which is basically a form of explanatory pluralism, while accepting and embracing plurality of evolutionary theories, focusing its energies on explaining evolutionary phenomena by integrating a selection from the multitude of theories, instead of wasting energy to futilely trying to unify them at the theoretical level.

5.2. Evolutionary Toolbox Analogy

How should integrative pluralism work in evolutionary biology? To illustrate this question, I devised an analogy of a toolbox. Hasok Chang (2012, 272-3) also mentions a toolbox analogy, as I have mentioned in the third chapter of this thesis.

Let us consider the homestead toolbox, designed for simple tasks needed in a home setting, such as plumbing, repairing home appliances, assembling ready-to-assemble furniture, and Do-It-Yourself (DIY) projects. This toolbox includes tools like hammers, screwdrivers, pliers, handsaw, wrenches, nails, screws with different sizes and shapes, and duct tape; however, due to the small size of the toolbox, tools are not diversified much. There are several options to choose from. For example, two different sizes of hammers, as well as five screwdrivers in various sizes and shapes to choose from, etc. Also, since this is a simple toolbox, it does not include advanced tools usually found in professional settings, such as chainsaws, wire strippers, torque wrenches, etc. Now, consider the tools that need to be used for different tasks, such as assembling furniture and a DIY project like a birdhouse for the garden. To complete these tasks, two sets of tools are required; some tools will be used in both tasks, while others will be used in only one. On the other hand, none of the tools used in the previous two tasks will probably be used for plumbing the kitchen sink.

In a different scenario, for assembling two pieces of furniture from two different brands, similar tools will likely be used but in different sizes and shapes, such as screwdrivers and hammers of varying sizes and shapes. In another scenario, in two very similar tasks, the same tools can be used in different orders. Sometimes, the homesteader who owns this toolbox needs to be creative due to the lack of specific tools designed for tasks or the absence of the exact type of tool; in such cases, another tool can be utilized, such as a flathead screwdriver instead of a Torx-head screwdriver. At the risk of pushing the boundaries of analogy, I would like to mention a cautionary tale related to Maslow's Hammer. Maslow's hammer is a cognitive bias that suggests that when you have only one tool, such as a hammer, you tend to see everything as a nail.

Let us apply this toolbox analogy to evolutionary biology. In this analogy, specific theories of evolution will be regarded as tools. Modern Synthesis (MS), Extended Evolutionary Synthesis (EES), and Integrative Evolutionary Pluralism (IEP) represent three distinct stances on the set of theories and tools of evolution. Modern Synthesis, with its limited selection of theories and reductive nature, is more like having and using only a screwdriver kit[5] - allowing only specific tasks within home settings—attempting to explain wide-ranging evolutionary phenomena with limited tools and theories. This stance suffers from Maslow's Hammer bias, which leads to the overlooking of certain evolutionary phenomena, particularly those that are emergent.

Extended Evolutionary Synthesis offers a more diverse range of tools and theories, albeit with a limited variety. However, due to its unificationist mindset, it is still rigid in structure. To use the same analogy, the stance is likened to using a fancy Swiss army knife instead of a complete toolbox.

Integrative Evolutionary Pluralism allows for a broader selection of tools and theories. It enables the use of tools independently of each other in various combinations and orders. An approach with such flexibility allows the explanation of diverse evolutionary phenomena and is more likely to use the complete toolbox of evolutionary theories.

5.3. Integrative Evolutionary Pluralism: How Should It Work?

Unlike ready-to-assemble furniture, a toolbox does not come with a manual. Similarly, integrative evolutionary pluralism also lacks a user's manual. However, I believe I can illustrate its basic principles in a general sense and provide concrete examples.

I suggest that Integrative Evolutionary Pluralism (IEP) is a loose set of specific evolutionary theories brought together in an integrative pluralist mindset. Unlike MS and EES, its objective is not to construct an all-encompassing, all-

[5] I must accept that this analogy suffers from oversimplification because if MS were a screwdriver kit, it would need to be exceptionally elaborate one. Nevertheless, it is still limited and restricted to a very similar set of tasks, unlike Dr. Who's sonic screwdriver, which is the science fiction equivalent of a magic wand capable of executing almost any task.

explaining, unified grand theory of evolution but to explain specific evolutionary phenomena. In IEP, the point of integration is not the theory but the explanation of the evolutionary phenomena. The tools used in a DIY project depend on the nature of the project, available tools, and the user's abilities and creativity. The application of specific evolutionary theories to explain an evolutionary phenomenon will depend on several factors, including the nature of the phenomenon and the researchers' aims and abilities.

In IEP, evolutionary theory becomes a meta-theory of evolution. Under the vast umbrella of evolutionary biology, numerous research areas exist, including population genetics, evolutionary-developmental biology, and niche construction, among others. Each research area (RA) encompasses multiple specific, competitive, and compatible theories. In other words, each is a set of specific theories (T), and evolutionary biology (EB) is a set of research areas (RA), as illustrated below (1-2).

$$EB = \{RA_1, RA_2, RA_3, \ldots, RA_n\} \tag{1}$$

$$RA_i = \{T_{i,1}, T_{i,2}, T_{i,3}, \ldots, T_{i,j}\} \tag{2}$$

Any evolutionary phenomenon[6] (EP) consists of different aspects (A). Each evolutionary phenomenon can be conceived as a set of aspects (3).

$$EP_i = \{A_{i,1}, A_{i,2}, A_{i,3}, \ldots, A_{i,n}\} \tag{3}$$

The researcher's focus on an aspect would depend on their aim (Aim). To explain an evolutionary phenomenon, researchers must select a group of theories relevant to the phenomenon they are interested in and according to their aims. The success of the explanation depends on both the selection of the theories and the researchers' abilities. Suppose we study a simple evolutionary

[6] I use evolutionary phenomenon in the simplest and widest sense of the word, which covers everything from the frequency change of an allele within a population to the adaptive radiation of major clades in geological time

phenomenon (EP_1) with a simple Aim_1. Due to the simplicity of Aim_1 and the simple nature of the phenomenon EP_1, the researcher decided to focus on only one aspect ($A_{1,1}$) of the phenomenon in question. Both the nature of the phenomenon and the researchers' aim are crucial in deciding which aspect will be investigated and how it will be studied. The question of how to choose a specific theory (T_1) from a research area (RA_1) is already dictated by the phenomenon's aspect and the researcher's aim.

To summarize, the researcher will select a specific theory (T_1) from a research area (RA_1) based on Aim_1, which determines the aspect of a simple evolutionary phenomenon ($A_{1,1}$). In other words, selecting T_1 from an RA_1 is a function of Aim_1 and $A_{1,1}$, and $A_{1,1}$ is a function of Aim_1, as abstracted out in equations (4-5) below:

$$A_{1,1} = f(Aim_1) \qquad A_{1,1} \in EP_1 \qquad (4)$$

$$T_{1,1} = g(Aim_1, A_{1,1}) \qquad T_{1,1} \in RA_1, A_{1,1} \in EP_1 \qquad (5)$$

Note that a different aim directed at the same evolutionary phenomenon will require the investigation of a different aspect of the same evolutionary phenomenon, which leads to the selection of another specific theory.

However, evolutionary phenomena are rarely simple. Instead, they are usually composed of a complex combination of different aspects that must be studied to make sense of them. This time, let us give a more complex and realistic example with a more ambitious aim, such as explaining an evolutionary phenomenon. A single researcher or a research group can never achieve this ambitious aim of explaining a complex evolutionary phenomenon. Instead, it requires integrating the efforts of several research teams from different research areas scattered through time and space.

Suppose we are aiming to explain a complex evolutionary phenomenon. The phenomenon’s complexity requires the investigators to integrate a selection of several specific theories from different research areas, say, $T_{1,1}$ from RA_1, $T_{2,1}$ from RA_2, and $T_{3,4}$ from RA_3, to study aspects of $A_{2,1}$, $A_{2,2}$, and $A_{2,3}$, respectively, of the phenomenon under investigation, EP_2 in this case. As depicted in equation (6), the explanation (E) of the selected aspects of the evolutionary phenomenon $E(A_{2,1}, A_{2,2}, A_{2,3})$ requires *ad hoc* integration (I) of those theories.

$$E(A_{2,1}, A_{2,2}, A_{2,3}) = I(T_{1,1}, T_{2,3}, T_{3,4}) \quad T_{i,j} \in RA_i, A_{2,j} \in EP_2 \tag{6}$$

Now, I would like to give two concrete examples. The first one is from Mitchell (2003, 194), who gives the complex case of the ecology of Lake Erie:

> Think of the changes of state of a complex ecosystem such as that of Lake Erie. There is an ongoing modeling project to consider the lake-wide effects of the invasion of zebra mussels, declining phosphorus loading, continuing toxic contamination, and fish harvesting on the structure of the fish community of that lake (see Culver 1999; Koonce and Locci 1999). The different factors contributing to these effects are large and diverse, including the chemicals silica, ammonia, nitrate, phosphate, total phosphorus, and phosphorus in sediments; five taxa of phytoplankton, six taxa of herbivorous zooplankton (including zebra mussel veligers), and three taxa of predatory crustacean zooplankton; zebra mussels and four taxa of other macrobenthos; and eleven taxa of planktivorous fish and six taxa of piscivorous fish. The model also represents seasonal and spatial variation in solar radiation. "Because phytoplankton, zooplankton, and planktivorous fish are sensitive to light, temperature, and nutrient concentrations they experience in non-linear ways the information represented in the model cannot be of 'average' values but rather of specific sampling locations in the lake" (Culver 1999). Features of the method of integration of these multiple factors for a single lake may be local to Lake Erie or may be symptomatic of a class of situations, but are unlikely to be global and algorithmic.

Although ecological in nature, this example inspired my integrative evolutionary pluralism. Mitchell (2003, 192), in that study, gives the case of Lake Erie as one of the three possible ways of integration: explanatory, concrete integration. The other two types of integration are "mechanical rules" and "local theoretical unification." I will not delve into the details of the other two because their applications are less general and cannot cover the whole of evolutionary biology.

Mitchell's (2003, 188, 194) Clear Lake and Lake Erie examples have three objectives. The first objective is to illustrate how complex an ecological model can get, with hundreds of variable components and constituting levels. Second, a concrete integrative model is unique and particular and does not apply to even a nearby lake due to the complex network of variables that constitute every lake, resulting in different structures and parameters. Thirdly, the "method of integration… may be local to Lake Erie or may be symptomatic of a class of situations but are unlikely to be global and algorithmic" (Mitchell 2003, 194). This third point is also crucial for integrative evolutionary pluralism.

Sandra D. Mitchell repeatedly emphasizes throughout her writings, spanning decades, that the method of integration cannot be algorithmic or global. She calls this "piecemeal integration" (Mitchell 1992, 143; 2003, 207).

To illustrate the importance of piecemeal integration's non-algorithmic and non-global nature and how it can be used in integrative evolutionary pluralism, I adapted and abstracted out Mitchell's other favorite example of the evolution of sociality in insects.

Most insects are solitary by nature, meaning they live by themselves except for a short period of time when males and females join for mating. On the other hand, some of the most successful insect groups live a tightly organized social life. This type of social organization is known as eusociality. To describe a society of animals as eusocial, three criteria need to be satisfied:

> …overlap of generations (i.e., mothers live sufficiently long to interact with their adult offspring); cooperative brood care (i.e., females provide some care to offspring that are not their own, and individual larvae are provisioned by more than one female); reproductive division of labor

> (i.e., some individuals of a group leave behind more offspring than others). (Otis 2005, 3447-8)

A wide range of living arrangements exists among different insect groups, spanning solitary and eusocial life. However, eusociality is a successful life strategy that has independently evolved at least eleven times in the insect group Hymenoptera, which includes ants, bees, and wasps (Anderson 1984, 178).

The origins and evolution of eusociality in insects have long drawn the attention of naturalists, including Charles Darwin. Darwin regarded insect eusociality as a challenge to his theory, and he attempted to explain this phenomenon through what is now known as kin selection (Anderson 1984, 165). Although kin selection theory remains popular among naturalists to explain insect eusociality, some naturalists question the necessity and effectiveness of this mechanism (Nowak, Tarnita, and Wilson 2010). I will not delve into the details of the kin selection theory and insect sociality debate as they may be too technical for my purposes. Below is a quote that perfectly summarizes the recent understanding of the topic, which can pave the way for the second integrative evolutionary pluralism example: "In place of a unifying theory, most scientists now recognize that each taxonomic group of insects has its own set of conditions that have influenced the evolution of sociality" (Otis 2005, 3450).

In our second example, I utilized the IEP as a potential way to solve the insect eusociality phenomena. Consider three distinct insect species living eusocial lives: an ant species, a bee species, and a termite species. Let us assume that their eusociality does not share a common ancestor, meaning they have evolved independently of each other. Ant and bee species belong to the same insect group, Hymenoptera, so they are more closely related to each other than termite species, which belong to another distinct group, closer to cockroaches. According to the IEP, we should not attempt to find an all-encompassing, all-explaining theory that explains the eusociality of these three species, which belong to three distinct groups. As the IEP's motto states: *The point of integration is not the theory but the explanation of the phenomenon.* This motto suggests that we should separately examine the eusociality of these three species as distinct phenomena. When we consider that they have independently evolved, this seems a reasonable action due to their separate phylogeny and history; it is highly likely that different combinations of evolutionary processes, forces, and mechanisms facilitated their separate origins. Of course, the opposite might also be the case: that evolutionary mechanisms, forces, and processes are involved in the evolution of these separately evolved cases of eusociality, with exact combinations, order, and force. However, this would be a striking coincidence considering the contingency of evolution.

Eusociality is a complex phenomenon; to explain it, we may need to refer to several specific theories from several research areas. To gain a fuller picture, we need to integrate different theories and explanations suggested by all of them. Research areas that seem relevant to the investigation of eusociality may include the following, at the very least: genetics, evolutionary developmental biology, semiochemistry (the study of chemical communication), and niche construction (the study of organisms' creation of their own environment). There may be other research areas and theories as well. Many aspects of the three species we are investigating should be studied and integrated. We can easily see that many research areas can actively contribute to understanding the evolution of eusociality in these three species. However, because each of the three species has independently evolved eusociality, the contribution of each research area to the understanding of its respective species may differ in both effect and degree.

In Figure 4, I illustrate how we can reach integrative explanations of three different evolutionary phenomena, namely eusociality in an ant, a bee, and a termite species. Here, I will only consider the bee eusociality; IEP will apply to the others in a similar way.

To explain bee eusociality, we should integrate different specific theories (T) from different research areas RA. The selection of research areas and specific theories within those areas to be used in an integrated explanation will be determined by the research group's aims. The research group's aims will also determine the aspects of bee eusociality that the group will study and, consequently, explain. In our example in Figure 4, a set of three aspects of bee eusociality is considered for the integrative explanation: inheritance, development, and nest-building behavior. To reach an integrative explanation of these three aspects, four specific theories are selected from four different sets of specific theories or research areas. These research areas are population genetics (PG), gene mutation (GM), evolutionary-development (ED), and niche construction (NC). The selected specific theories from these research areas to reach an integrative explanation of bee eusociality are as follows: $T_{PG, n}$; $T_{GM, 1}$; $T_{ED, 2}$; $T_{NC, n}$.

Below are the formal representations of integrative explanations for three different eusociality phenomena in ants, bees, and termites, as illustrated in Figure 4.

$$EP_{\textbf{Ant Eusociality}}: E(A_{AE,I}, A_{AE,D}, A_{AE,N}) = I(T_{PG,1}, T_{GM,n}, T_{ED,1}, T_{NC,2}) \quad (7)$$

$$EP_{\textbf{Bee Eusociality}}: E(A_{BE,I}, A_{BE,D}, A_{BE,N}) = I(T_{PG,n}, T_{GM,1}, T_{ED,2}, T_{NC,n}) \quad (8)$$

$$EP_{\textbf{Termite Eusociality}}: E(A_{TE,I}, A_{TE,D}, A_{TE,N}) = I(T_{PG,2}, T_{GM,2}, T_{ED,n}, T_{NC,n}) \quad (9)$$

Apart from the abstract formulizations, could it be shown in a case study that this way of doing science is possible? Although it is very tempting to attempt such a feat, I have realized that this is hard to achieve by only philosophical theorizing. That is because the integration of specific theories requires empirical investigation and the development of ad hoc theories to stitch the specific theories together, which is probably beyond the capabilities of a single person who is not proficient enough in several research areas that are attempted to integrate. This means that IEP is an inter and transdisciplinary enterprise.

I would like to conclude this chapter by restating the motto of IEP, namely, that the point of integration is not the theory itself, but rather the explanation of the phenomena under investigation. I believe this motto would spare us from attempting to achieve the unachievable, overly ambitious objectives, such as synthesizing a comprehensive theory of evolution.

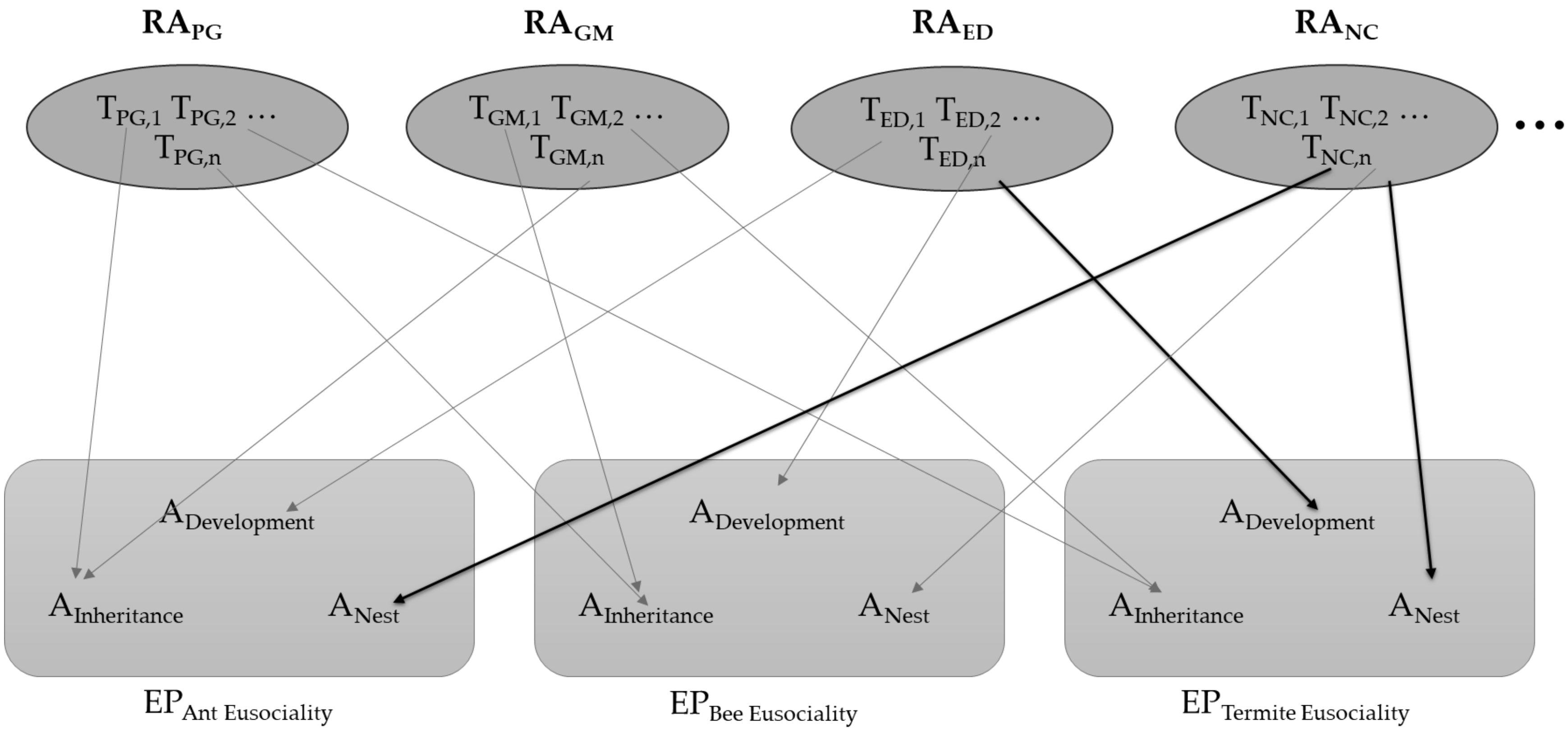

Figure 4. Illustration of integrative pluralism in eusocial insects. EP: Evolutionary Phenomena, A: Aspect, T: Theory, RA: Research Area, PG: Population Genetics, GM: Gene Mutation, ED: Evo-Devo, NC: Niche Construction.

CHAPTER 6

CONCLUSION

With the ever-increasing plurality of evolutionary theories, pluralism is the inevitable direction for evolutionary biology. However, MS and EES clash for dominance to make sense of this plurality. I believe a possible third path has yet to be realized: integrative evolutionary pluralism. Below are the three possible scenarios for the success of these three different paths.

In the case of MS's success, evolution will have a much narrower, isolated, and homogeneous meaning based on population genetics. However, due to the discovered plurality of evolution-like phenomena, other evolutionary disciplines will inevitably continue to be established, which are excluded from evolutionary biology. This situation will create a much more fragmented scientific scene than the MS supporters would have intended.

I believe EES' success is possible, but because it also suffers from the same disadvantages of the unificationist mindset, only less severely than MS supporters. Their effort to distance themselves from reductionism may lead to a more pluralist, less loosely structured, and inclusive unified theory of evolution. However, this is only possible by successfully formulating a New (Extended) Synthesis. Due to the current fractured structure of evolutionary biology, this can only be possible with the same strategy the founders of MS used. This strategy excludes evolutionary phenomena that do not fit with the

New (Extended) Synthesis. Eventually, this will cause dissent, and they will share the same fate with MS.

I conclude that integrative evolutionary pluralism, based on integrative pluralism, is the third, more stable, but yet-to-be-realized path for evolutionary biology. In this framework, different concepts and theories of evolutionary processes will be seen as tools in the evolutionary biology's toolbox. Individual evolutionary phenomena will be explained according to their fitness with different theories, conceptions, and mechanisms of evolution.

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APPENDICES

A. TURKISH SUMMARY / TÜRKÇE ÖZET

Günümüz evrimsel biyolojisi hala erken yirminci yüzyılda geliştirilmiş olan modern sentezin çizdiği kuramsal çerçeve içinde işlemektedir. Fakat modern sentezin ortaya çıkışından itibaren ona yönelik karşı çıkışlar olmuştur. Ne var ki bunlar modern sentez destekçileri tarafından başarıyla savuşturulmuştur. Yirmi birinci yüzyılın başlarında bu geçmiş itirazlardan da ilham alan yeni bir karşı çıkış vücut bulmuştur. Destekçileri tarafından genişletilmiş evrimsel sentez (extended evolutionary synthesis) olarak adlandırılan bu karşı çıkış yirmi yıla yakın bir süredir varlığını sürdürmeye devam etmektedir. Dahası modern sentez destekçilerinin rakiplerini alt etmek için daha önce kullandıkları stratejiler bu kez işe yaramıyor gibi görünmektedir, en azından şimdilik. Diğer yandansa genişletilmiş evrimsel sentez, her ne kadar modern sentezin eleştirilerine dirençli görünse de, evrimsel biyoloji içinde hâlâ marjinal bir konumdadır. Modern sentez-genişletilmiş evrimsel sentez tartışmasının sonucu henüz meçhul olsa da bize bilim felsefesi açısından verimli bir mecra sunmaktadır: Bilimsel değişim ve ilerlemenin doğası, özellikle kavramsal/kuramsal değişim, bilimsel kuramlar ve paradigmaların yapısı gibi konularda bu tartışma bize değerli bir veri kaynağı sunmaktadır.

Bu tezin biri tarihsel diğeri felsefi iki temel dayanağı vardır. Tarihsel dayanak, evrimsel biyolojinin, özellikle modern sentezin, önde gelen tarihçilerinden

Vassiliki Betty Smocovitis'in çalışmalarında bulunabilir. Smocovitis'e (1992) göre modern sentezin gerçekleşmesini sağlayan esas itici güç biyolojinin birliği idealidir. Bu tezde bu birlik idealinin modern sentez-genişletilmiş evrimsel sentez tartışmasında da etkisini sürdürdüğünü göstermeye çalışıp, bu ideali artık bir kenara koymamız gerektiğini iddia ediyorum.

Tezin ikinci ve felsefi dayanağı ise, biyolojiyi birleştirmekten vazgeçersek ne yapmamız gerektiği sorusuna odaklanıyor. Bu soruya bilim felsefesinin önde gelen isimlerinden biri olan Sandra D. Mitchell'in (2003, 2012) bize birlik yerine bilimsel çoğulculuğu salık veren entegre[7] çoğulculuğu aracılığıyla yanıt veriyorum. Bilimsel çoğulculuk biyoloji felsefesinde güçlü bir akımdır ve evrim kuramı bağlamından daha önce pek çok kez önerilmiştir. Dolayısıyla benim bu tezdeki önerim sıra dışı ya da daha önce duyulmamış bir şey değildir. Dahası kimi bilim felsefecileri genişletilmiş evrimsel sentez hareketinin başlangıcından beri bilimsel çoğulculuğun evrim kuramına uygulanabileceğini belirtmişlerdir.

Bilimsel çoğulculuğun özel bir türü olan, entegre çoğulculuğu evrim kuramına uygulayacağım. Entegre çoğulculuk karmaşık biyolojik ve sosyal olgular için özel olarak tasarlanmış bir çoğulculuk biçimidir. Bildiğim kadarıyla modern sentez-genişletilmiş evrimsel sentez tartışmasına entegre bilimsel çoğulculuk daha önce hiç uygulanmamıştır. Bu tezin hedefi bu uygulamayı yapmaya çalışmaktır.

Şimdi ilk önce tarihsel dayanağa eğilelim, bunun için evrim düşüncesinin tarihine bakmamız gerekiyor. Evrim düşüncesinin tarihini Antik Yunan'a kadar

[7] "Integrative"in Türkçe karşılığı olarak "entegre"yi kullanmayı tercih etmemin nedeni "bütünleyici" ya da "birleştirici" gibi daha Türkçe karşılıkların monist yani tekçi tınılarının olmasıdır, bunun için daha iyi bir karşılık bulunana kadar entegreyi kullanmayı tercih ettim.

götürenler olsa da evrimin bir bilim olarak başlangıcının tarihinin 1859, yani Charles Darwin'in Türlerin Kökeni adlı eserinin yayınlanması olduğu genel kabul görmüştür. Darwin'in en büyük bilimsel başarısı eğitimli insanların çoğunu evrimin gerçekleştiğine ikna etmesidir. Ne var ki Darwin, insanları evrimin nasıl gerçekleştiğini açıklayan temel mekanizmasına, yani doğal seçilime, ikna etmekte başarılı olamamıştır. Darwin hayattayken evrim kuramının yaygın kabul gördüğüne bizzat şahit olmuştur ancak doğal seçilime karşı şiddetli bir muhalefetle karşılaşmıştır. Darwin'in ölümünden sonra durum doğal seçilim için daha da kötüye gitmiştir. Darwin'in ölümünden modern senteze kadar geçen bu yaklaşık elli yıllık dönemi Julian Huxley, Darwinciliğin Sönümlenme[8] dönemi olarak adlandırır (Bowler 2009).

Darwinciliğin sönümlenmesi geleneksel evrim tarihi anlatılarında bir karanlık çağ olarak anlatılsa da bu dönemi Darwinci olmayan evrim kuramları açısından tam da aksine bir Kambriyen patlaması dönemidir. Bu dönemde Darwin'in doğal seçilim yoluyla evrim kuramına karşı pek çok kuram ortaya atılmış ve dönem boyunca bu kuramlar modern sentezin ortaya çıkışına kadar kısa da olsa altın çağlarını yaşamışlardır. Bu dönemde ortaya atılan ve kısmen birbiriyle kesişen, Darwin'in kuramına rakip evrimci akımları şu ana başlıklar altında toplayabiliriz: Neo-Lamarckçılık, ortogenezcilik, sıçramalı evrimciler ve Neo-Darwincilik (Bowler 2009).

Darwin'in kendisi de bir miktar Lamarckçıydı, kuramı doğal seçilimin yanı sıra Lamarckçılığın alamet-i farikası olan kullanıma dayalı kazanılmış özelliklerin kalıtımına izin veriyordu. Ne var ki Neo-Lamarckçılar, doğal seçilimi tamamıyla bir kenara itip sadece kazanılmış özelliklerin kalıtımına

[8] "Eclipse of Darwinism"indeki "eclipse"in Türkçe karşılığı olarak anlamı daha iyi verdiğini düşünerek "tutulma" yerine "sönümlenme"yi tercih ettim.

odaklandılar, ayrıca Lamarckçıların bir kısmı aynı zamanda da ortogenezciydiler. Ortogenezcilere göre evrim organizmalarda içsel olarak mevcut olan bir güç tarafından yönlendiriliyordu, varyeteler bu gücün sayesinde ortaya çıkıyordu. Bu gücün mahiyeti genellikle açıklanmıyordu. August Weismann'ın öncülük ettiği Neo-Darwinciler ise Darwin'in kendisinin aksine Lamarckçılığa kesinkes karşıydılar. Weismann'ın germplazm modeli kazanılmış özelliklerin kalıtımını tamamıyla dışlıyordu. Biyometrikçiler olarak bilinen bir diğer grup da Neo-Darwinciliğe dahil edilebilir. Biyometrikçiler yabanıl popülasyonlarda görülen varyasyonlar ve bu varyasyonlara etki eden seçilim baskısını istatistiksel yöntemler kullanarak anlamaya ve kalıtım sorununu çözmeye çalıştılar. Darwinciliğin sönümlenme dönemine ait son evrimci akım; sıçramalı evrimciler, mutasyoncular ya da Mendelciler olarak birden fazla isimle anılır. Onlara göre mutasyon olarak adlandırdıkları ani kalıtsal değişimler yeni türlerin ortaya çıkmasını sağlıyordu. Biyometrikçilerin aksine laboratuar koşullarında küçük popülasyonlar üzerinde kontrollü çalışmalar yapan Mendelciler, Darwinci ve Neo-Darwinci seçilim ve adaptasyonculuğu reddediyorlardı (Bowler 2009).

1920'lerden itibaren Darwinci olmayan evrim kuramları büyük bir oranda dönemin yeni bilimi genetikteki gelişmeler sonucunda popüleritelerini ve bilimsel desteklerini kaybetmeye başladı. Kazanılmış özelliklerin kalıtımının mümkün olmadığı fark edilince Neo-Lamarckçılık desteğini kaybetti. Mutasyonların yönlendirilmiş değil rasgele olduğunun fark edilmesi de ortogenezi desteklenemez hale getirdi. Son olarak mutasyonların etkilerinin yeni türler ortaya çıkarmayacağının anlaşılması da sıçramalı evrimciliği gündemden düşürdü. Doğal seçilim hem genetikçiler hem de doğa bilimciler arasında yeniden destek kazandı. Bunlar modern sentezin ilk ayak sesleriydi (Bowler 2009). Modern senteze ulaşmada ilk adım mutasyonların rasgele gerçekleştiğine ve organizmaların özellikleri üzerinde ancak küçük değişikliklere yol açtığına dair yeni bir anlayışın gelişmesiydi. Mutasyonların yol açtığı bu küçük değişikliklerin etkileri de oldukça değişkendi: Kiminin etkileri oldukça önemsizken bazıları da zararlıydı. Bir diğer gelişme de parçacıklı bir kalıtımın sürekli varyasyona yol açabileceğinin anlaşılmasıydı. Bu gelişmeler popülasyon genetiğinin geliştirilebilmesinin önünü açtı. Matematiksel bir bilim olan popülasyon genetiği Neo-Darwinci biyometrikçilerin savlarını destekledi. Buna göre kalıtsal bir özellik eğer onu taşıyan organizmaya bir üreme avantajı sağlıyorsa bu kalıtsal özelliğin sıklığı popülasyon içinde artacaktı ve zararlı bir kalıtsal özellik içinse tersi doğruydu. Popülasyon genetiği çalışmalarının matematiksel doğası onun doğa bilimciler arasında anlaşılmasını zorlaştırsa da sonuçları Neo-Lamarckçılık'ın reddedilip doğal seçilimin tekrar kabul edilmesine yeterli olmuştu. Theodosius Dobzhansky'nin doğa bilimciler ve popülasyon genetikçiler arasında köprü kuran çalışmalarının ise modern sentezin yükselişine işaret ettiği çoğunlukla kabul edilir. Ne var ki modern sentezin tam mahiyeti ve kimler tarafından gerçekleştirildiği tartışmalıdır. Özellikle Ernst Mayr, doğa bilimcilerin çalışmalarının da modern senteze ulaşılmasında önemli katkıları olduğunda ısrarcıdır ve popülasyon genetiği merkezli anlatıya karşı çıkar. Stephen Jay Gould ise modern sentezin iki evresinden bahseder, birinci sınırlanma evresinde evrim kuramı Darwinci olmayan kuramların etkisinden kurtarılır. Gould, modern sentezin henüz çoğulcu olduğu bu ilk evreye olumlu yaklaşırken, katılaşma evresi dediği ikinci evreyi ise eleştirir. Katılaşma evresinde Neo-Darwinciliğin evrimin tek geçerli açıklaması olduğu anlayışının hâkimiyet kazandığını söyler (Bowler 2009).

Vassiliki Betty Smocovitis'e (1992) göre ise modern sentezin popülasyon genetikçi mimarları ilhamlarını fiziksel bilimlerden ve mantıkçı pozitivistlerin bilimin birliği hareketinden almışlardır. Mantıkçı pozitivistler tüm bilimleri tek bir fizikalist çatı altında toplamayı ve onu metafizik unsurlardan arındırmayı hedeflemişlerdir. Smocovitis modern sentezcilerin temel motivasyonlarının biyolojiyi evrim çatısı altında birleştirmek olduğunu iddia eder. Ne var ki modern sentezin ileri gelen bilim insanlarından olan Ernst Mayr (1993) sonuç biyolojinin birliği olsa da modern sentezin inşası sırasında böyle bir motivasyonları olduğu fikrini reddeder. Ben bu tezde Smocovitis'in iddiasını bir adım daha öteye götürüp, bilimin birliği idealinin hâlâ etkin olduğunu ve modern sentez-genişletilmiş evrimsel sentez tartışmasında belirleyici bir etkisi olduğunu iddia edeceğim. Bilimin birliği ideali yerine bilimsel çoğulculuğun modern sentez-genişletilmiş evrimsel sentez tartışmasının çözümlenmesini sağlayacağı iddiam ise tezimin ikinci dayanak noktasıdır. Modern sentez-genişletilmiş evrimsel sentez tartışmasına katılan bazı felsefeciler evrim kuramı için çoğulcu bir yaklaşımın gerekli olduğunu zaten ifade etmişlerdi. Alan Love (2010) evrim kuramını tasvir etmenin birden fazla yolu olduğunu ve her bir alternatifin avantajları ve dezavantajları olduğunu söyler.

Evrim kuramlarının çoğulluğu sorununa girişmeden önce bilimsel çoğulculuğu açıklamak yerinde olur. Bilimlerin çoğulluğu görmek için bilim tarihine bir bakış atmak yeterli olacaktır. Ancak yakın zamana kadar hem bilimciler hem de bilim felsefecileri bu çoğulluğu aşmanın yollarını aramışlardır. Ne var ki bu bilimleri tek bir birleşik çatı altında toplama hedefi yirminci yüzyılın ilk yarısında bir çıkmaza ulaşmıştır ve 1970 ve 1980'lerde bazı bilim felsefecileri bilimin çoğulluğunun aşılması gereken bir sorun değil kabul edilip kutlanması gereken bir durum olduğunu iddia etmeye ve bu amaçla bir program oluşturmaya başlamışlardır. Bu bilim felsefecileri bilimsel çoğulcular olarak bilinir.

Bilimsel çoğulcular için bilimlerin çoğulluğu aşikardır, onlara göre bilimsel çoğulluğun dört temel kaynağı vardır: bunlar ontolojik, epistemolojik, sosyolojik ve metodolojik kaynaklardır. Pek çok bilimsel çoğulcu bilim felsefecisi dünyanın, karmaşıklığı ve düzensiz ve/veya yamalı yapısı gibi özelliklerinin altını çizmiştir. Bu bilim felsefecilerine göre dünyanın bu özellikleri onu bilimsel kesinlik, bütünlük ve birlik içinde tasvir etme hedeflerine engel olur. Bunlar çoğulluğun ontolojik kaynaklarıdır (Ludwig ve Ruphy 2021).

Çoğulluğun epistemolojik kaynakları ise bilimin çeşitli ve çoğul tasvir biçimleridir: Kuramlar, modeller, açıklamalar çoğulluk gösterir. Çoğulcu felsefecilere göre bilimsel pratiğin bu çoğul yapısının onu bilimsel birlik ideali ile çatışma içine sokar (Ludwig ve Ruphy 2021).

Çoğulluğun sosyolojik kaynaklarının iki boyutu vardır. Bunlardan birincisi fazla tartışmalı değildir, bilimin sosyal örgütlenmesi içinde farklı disiplinler ve bilimsel topluluklar vardır ki bunların çokluğu bilimin çoğulluğunu besler. İkinci boyut ise politik doğası nedeniyle çok daha tartışmalıdır. Buna göre toplumların çeşitliliği bilimsel çoğulluğa yol açmaktadır (Ludwig ve Ruphy 2021). Bu sosyolojik boyut özellikle feminist bilim felsefecileri tarafından ayrıntılarıyla işlenmiştir (Harding 2015).

Son olarak bilimin metodolojik çeşitliği tartışmasız bir konudur, pek çok farklı disiplinin kendine özgü bilimsel metotları vardır (Ludwig ve Ruphy 2021).

Kellert vd. (2006, x) bilimsel çoğulculuğu bilimsel tekçiliğin (monizm) karşısına koymuş ve tekçiliği şöyle tanımlamışlardır: Bilimsel tekçiliğe göre bilimin amacı doğal dünyanın tek ve bütüncül bir tasvirini belirli tek bir temel ilkeler kümesine dayanarak çıkarmaktır. Bilimsel tekçilere göre bilimin mevcut çoğulluğu geçicidir ve onun henüz olgunlaşmamış olmasından kaynaklanmaktadır ve yeterli zaman verilirse bu çoğulluk ortadan kaldırılacaktır.

Bilimsel çoğulcularsa bilimde görülen çoğulluğu doğanın karmaşıklık ve belirsizlik gibi niteliklerinin ve insanın bilişsel yetilerinin bir sonucu olarak görürler. Bu çoğulluğun bir sorun değil aksine bilimin önemli ve faydalı bir niteliği olduğunu düşünürler. Onlara göre bilim, insanların çeşitlilik gösteren ilgi ve çıkarlarına bu çoğulluk içinde daha iyi hizmet edecektir (Chang 2012).

Ne var ki bilimsel çoğulcular pek çok farklı çoğulculuk modeli tasvir etmişlerdir. Ben bu tezde Sandra D. Mitchell'in entegre çoğulculuk dediği çoğulculuk modelini temel aldım ve onu modern sentez-genişletilmiş evrimsel sentez tartışmasına uygulamaya çalıştım. Mitchell'in entegre çoğulculuğunu tercih etmemin nedeni onun temel olarak karmaşık biyolojik ve sosyolojik olgular göz önünde bulundurularak tasarlanmış olmasıdır. Mitchell'in çoğulluk için verdiği pek çok örnek evrimsel olgularla ilgilidir. Bu özellikleri entegre çoğulculuğu modern sentez-genişletilmiş evrimsel sentez tartışmasını incelemeye elverişli kılıyor.

Mitchell'in (2012) entegre çoğulculuğun, gerekçelendirmesini biyolojik ve sosyal olguların karmaşıklığı ve olumsallığından alır. Mitchell, karmaşık olguların beliren (emergent) özellikleri ve bütünü kapsayan yasalarının yokluğu nedeniyle indirgeme çabalarına direndiğini söyler. İndirgeme geleneksel bilimsel epistemolojinin doğal olguları açıklama yoludur ve bilimsel devrimden bu yana hayret verici bir başarıyla çalışmıştır. Ne var ki bilim yapmanın bu biçimi erken yirminci yüzyılda önce fizikte sonra diğer bilimlerde doğal sınırlarına ulaşmıştır. Geleneksel bilimsel epistemoloji özellikle biyolojik ve sosyolojik olguların çoğunu açıklamada yetersiz kalmaktadır. Mitchell'e (2012, 106) göre karmaşık olguları açıklamada ancak "indirgemeci olmayan, farklı olgusal düzeyleri entegre eden ve faydacı biçimde hedeflenmiş açıklamalar" başarılı olabilir. Mitchell'in entegre çoğulculuğu geleneksel bilimsel epistemolojiyi reddetmez ancak onun yetersiz kaldığı yerlerde bilimsel epistemolojiyi genişletir. Bu tezde entegre çoğulculuğun evrim kuramına uygulayarak modern sentez-genişletilmiş evrimsel sentez tartışmasının çözümlenmesine dair bir öneride bulundum. Bu önerime entegre evrimsel çoğulculuk dedim. Entegre evrimsel çoğulculuğu açıklamaya geçmeden önce modern sentez-genişletilmiş evrimsel sentez tartışmasının seçici ve eleştirel bir incelemesini sunacağım. Bu incelemeyle hem modern sentezin hem de daha zayıf da olsa genişletilmiş evrimsel sentezin bilimin birliği hareketinin etkisi altında ve tekçi eğilimleri olduğunu göstermeye çalışacağım. Bunların yerine çoğulculuğu merkeze alan entegre evrimsel çoğulculuğu koymayı önereceğim. Hem modern sentez hem de genişletilmiş evrimsel sentez tüm evrimsel olguları açıklayabilecek bir kuramsal çatı sağladıkları iddiasındalar. Ne var ki evrimsel olguların karmaşıklığı ve çeşitliliği bu iddianın pratikteki uygulanabilirliğini oldukça şüpheli kılmaktadır. Bu tezde her şeyi kapsayan ve açıklayan bir kuram arayışını terk etmeyi ve eldeki soruna entegre çoğulculukla bakmayı öneriyorum. Bu tezin düsturu şudur: Entegre çoğulculukta entegrasyonun hedefi kuram değil olgulardır.

Modern sentez, evrimin yirminci yüzyılın başlarından itibaren en başarılı ve baskın anlayışıdır ve yaygın bir biçimde kabul edilir. Ne var ki modern sentezin başlangıcından beri onu yetersiz bulanlar olmuştur. Motoo Kimura, Stephen Jay Gould ve Niles Eldredge modern sentezin yetersizliğine karşı yeni evrimsel kuramlar önerenlerden bazılarıdır. Ne var ki bu öneriler modern sentez karşısında başarılı olamamışlardır.

Yirmi birinci yüzyılın başlarında genişletilmiş evrimsel sentez adıyla, modern senteze yeni bir alternatif önerilmiştir. Genişletilmiş evrimsel sentezin modern senteze yönelik eleştirileri öncekilerle benzerdir, ancak destekçileri daha çeşitli, çok sayıda ve daha iyi örgütlenmiştir. İlk önerildiğinden beri geçen yaklaşık yirmi yılda marjinal bir öneri olarak kalmaktan kurtulamamışsa da modern sentez tarafından yenilgiye uğratılacak gibi de görünmemektedir. Genişletilmiş evrimsel sentezin temel stratejisi modern sentezi kabul etmekle birlikte onu genişletmek iddiasında bulunmaktır.

Genişletilmiş evrimsel sentezin literatürde ilk kez görüldüğü iki makale de 2007 yılında yayınlanmıştır. Bu iki makalenin yazarları, Massimo Pigliucci ve Gerd B. Müller, paradigma değişimi ya da kuramsal alt-üst oluş gibi aşırı iddialardan kaçınırlar. 2010 yılında Pigliucci ve Müller'in birlikte yayınlandığı derleme kitap Evolution—the Extended Synthesis'de farklı disiplinlerden çeşitli görüşler temsil edilmiştir. Pigliucci ve Müller'in ortaklaşa yazdığı kitabın giriş bölümünde yer alan bir tasvir birbiri içine geçmiş üç küme ile evrim kuramının gelişimini göstermektedir. Diğer iki küme tarafından kapsanan en içerdeki küme evrim kuramının Darwin'in önerdiği versiyonunu temsil eder. Bu içteki kümenin elemanları varyasyon, kalıtım ve doğal seçilimdir. Modern sentezi temsil eden ortadaki ikinci kümeyse Darwin'in kümesi dışında beş eleman içerir. Bunlar gen mutasyonu, Mendelci kalıtım, popülasyon genetiği, olumsallık ve türleşmedir. En dıştaki küme genişletilmiş evrimsel sentezi temsil eder ve önceki iki kümenin yanı sıra şu elemanları içerir: Evo-devo kuramı, esneklik ve bağdaşma, niş inşası, kopyalayıcı kuramı, evrilebilirlik, çok-düzeyli seçilim ve genomik evrim. Bu tasvirdeki her bir eleman evrim kuramının unsurlarını temsil etmektedir (Pigliucci ve Müller 2010a).

2022 yılında genişletilmiş evrimsel sentezcilerin tamamladığı bir projenin raporunda Lynn Chiu evrimsel biyolojinin genişleme sürecini anlatan bir başka tasvir sunar. Bu tasvirde tangram bulmacası metafor olarak kullanılmıştır. Bu tasvir önceki içi içe geçmiş kümeler tasvirinden daha sofistikedir. Bu tangram metaforundan üç aşamalı bir genişleme süreci tasvir edilir. İlk aşamada daha küçük modern sentezi temsil eden tangram çözümü görülür. Üçüncü aşamadaysa daha büyük, genişletilmiş sentezi temsil eden çözüm vardır. Bu iki çözüm arasındaki aşamadaysa evrim kuramına eklenen yeni öğeleri temsil eden yeni bulmaca parçalarının eklenmesiyle uyumsuz geçici bir durum bulunur. Genişletilmiş evrimsel sentezin hem kümeler hem de tangram ile tasviri tek bir doğru çözümün olduğu tekçi bir anlayışı temsil etmektedir ve bu açıdan modern sentezden çok farklı değildir. Sadece modern sentezden daha fazla parçası/öğesi olan ama yine de tekçi olan bir anlatıyı gaye edinmektedir. Pek çok genişletilmiş evrimsel sentez destekçisi evrim kuramlarının çoğulluğunu kabul etse de az önce söylediğimiz gibi bu çoğulluğu, entegrasyon, sentez ya da birlik yoluyla aşmayı hedeflerler. Tam da bu yüzden Reis ve Araujo (2020) genişletilmiş evrimsel sentez isimlendirmesindeki hem "genişletilmiş," hem de "sentez" ifadelerine karşı çıkarlar. Öncelikle genişletilmiş evrimsel sentezcilerin evrim kuramında önerdiği değişiklikler basit bir kapsam arttırmadan çok daha büyük ölçeklidir, ikincisi "sentez" ifadesi genişletilmiş evrimsel sentezcilerin niyet ettikleri çoğulluğa göre çok daha muhafazakar bir terimdir. Stoltzfus (2017) de, bize evrimin büyük kuramı sevdasından vazgeçmeyi ve yönümüzü evrimsel modların çoğulluğuna dönmeyi salık verir.

Entegre evrimsel çoğulculukta ben de, tam Reis ve Araujo ile Stoltzfus'un önerilerine benzer bir öneride bulunuyorum. Entegre evrimsel çoğulculuk temel olarak açıklamada çoğulculuğun bir biçimidir: Evrim kuramlarının çoğulluğunu kabul edip kutlarken, enerjimizi, beyhude yere bütün bu farklı kuramları birleştirmeye harcamak yerine bu kuram çoğulluğundan yapılan seçkilerle evrimsel olguları açıklamaya vakfetmemiz gerektiğini söylüyorum.

Entegre evrimsel çoğulculuğu bir alet kutusu benzetmesiyle açıklayabiliriz. Buna göre her bir özgül evrimsel kuram, evrimsel açıklamaları yapmakta kullanacağımız bir alet kutusunun elemanları olarak düşünülebilir. Entegre evrimsel çoğulculukta amaç modern sentez ya da genişletilmiş evrimsel sentezdekinin aksine bütün evrimsel olguları açıklayabilecek bir büyük-birleşik kuram inşa etmek değil tek tek evrimsel olguları açıklamaktır. Özgül kuramların bir olguyu açıklama sırasında kullanımı olgunun doğasından, araştırmacının yetenek ve amaçlarına kadar pek çok faktöre bağlıdır. Entegre evrimsel çoğulculukta evrim kuramı bir meta-kuram halini alır. Evrimsel biyolojinin geniş şemsiyesi altında, popülasyon genetiği, evrimsel-gelişim biyolojisi ve niş inşası gibi pek çok araştırma alanı bulunur. Her bir araştırma alanı kendi içinde birden fazla birbiriyle uyumlu ya da rekabet halinde özgül kuramlar bulundurur. Diğer yandan her bir evrimsel olgunun farklı veçheleri vardır. Diğer bir deyişle, her bir evrimsel olgu bir evrimsel veçheler kümesi olarak düşünülebilir. Bir araştırmacının bir evrimsel olgunun hangi veçhesine odaklanacağı o araştırmacının amaçları tarafından belirlenir.

Araştırmacılar bir evrimsel olguyu açıklamak için kendi amaçlarına uygun veçhelerle ilgili farklı araştırma alanlarından farklı özgül kuramların bir seçkisini oluşturmalıdır. Evrimsel bir açıklamanın başarısı hem bu özgül kuramlar seçkisinin isabetliliğine hem de araştırmacıların kabiliyetlerine bağlıdır. Aynı evrimsel olguya yöneltilmiş farklı amaçlar, farklı veçheleri araştırmayı gerektirir, bu da farklı bir özgül kuramlar seçkisinin oluşturulması gerektiği anlamına gelir. Bunu farazi bir örnekle açıklamak gerekirse, pek çok arı türü arasından birinin, örneğin bal arıların ösosyalitesini (eusociality) açıklamak için farklı araştırma alanlarından farklı özgül kuramların entegrasyonuna ihtiyaç vardır. Ancak bir başka böcek grubuna örneğin termitler ya da yabanarıları grubuna ait bir türün ösosyalitesini açıklamak için büyük olasılıkla farklı ya da aynı araştırma alanlarından farklı bir özgül kuramlar seçkisine ihtiyaç duyulacaktır.

Evrim kuramlarının durmaksızın artan çoğulluğu içinde çoğulculuk evrimsel biyoloji için mecburi istikamettir. Her ne kadar modern sentez ve genişletilmiş evrimsel sentez bu çoğulluğu kendilerince anlamlandırmak için birbirleriyle çatışsalar da, bu tezde açıklamaya çalıştığım gibi mümkün olan üçüncü bir yol daha vardır. Bu da entegre evrimsel çoğulculuktur.

Aşağıda bu üç farklı patikanın her birinin zaferi durumunda gerçekleşebileceklere dair üç farklı olası senaryoyu bulabilirsiniz. Modern sentezin zaferi durumunda evrimin popülasyon genetiğini temel alan çok daha dar, yalıtılmış ve yeknesak bir anlamı geçerlilik kazanacaktır. Ancak çoktan keşfedilmiş evrim-benzeri biyolojik olgular bu evrim tanımından dışlanacaktır. Bu olguları inceleyen ve açıklayan disiplin ve araştırma alanları ortadan kalkmayacağına göre biyoloji orijinal modern sentezcilerin niyetlerinin aksine biyolojide birliğe değil çok daha parçalı bir bilimsel manzaraya neden olacaktır.

Genişletilmiş evrimsel sentezin zaferi de mümkündür. Ancak, tezimde göstermeye çalıştığım gibi, modern sentezden daha az olsa da genişletilmiş evrimsel sentez de, modern sentez gibi tekçilikten muzdariptir. Bu nedenle geçici bir süre için modern sentezden daha çoğulcu, daha gevşek yapıda bir büyük birleşik evrim kuramı inşa edebilme ihtimali, düşük de olsa, mevcuttur. Ancak bu büyük birleşik kuram da yeni keşfedilecek kuramları içermediğinden ya da bir kısım kuramı inşa sürecinde dışlamak zorunda kalacağı için, eninde sonunda modern sentezle aynı kaderi paylaşacak ve yetersizlikle suçlanacaktır.

Önerdiğim ancak henüz gerçekleşmemiş olan üçüncü yol, entegre evrimsel çoğulculuk, hem modern sentezden hem de genişletilmiş evrimsel sentezden daha kararlı bir yapı önermektedir. Bu yapıda evrimsel süreçlere dair farklı kavram ve kuramlar birer el aleti gibi görülecek ve evrimsel biyolojinin alet çantasında yetkinliklerine göre yer almaya hak kazanacaklardır. Her bir evrimsel olgu farklı kuramlar, kavrayışlar ve mekanizmalar tarafından açıklanacaktır.

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