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# Marxism and the Crisis in Modern Biology

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### Abstract

Modern biology, especially biomedical research, is currently embroiled in crisis. This crisis is not unsurprising considering the bourgeois culture and philosophy that has guided scientific research since the Molecular Biology revolution and aided by the increasing public-private partnerships. The resolution of this crisis can only be achieved through a radical shift in how we understand and practice science, and the Marxist philosophy of dialectical materialism can provide us with the necessary tools to do so. In this paper, I provide a brief overview of the development of dialectical materialism and its application over the years to understanding the natural world. I also show that biologists have also independently adopted similar views as research has progressed over the years. Lastly, I argue that the epistemological crisis and the subsequent crisis observed in the practice in science are two sides of the same coin, and that Marxist philosophy can help break out of this vicious cycle.

**Keywords:** dialectics, Marxism, biology, biomedical research, materialism

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## 1. Introduction

...science, in all its senses, is a social process that causes and is caused by social organization. (Levins and Lewontin, 1985)

In 2014, the prominent cancer researcher Robert Weinberg published a paper admitting that the current paradigm of cancer research, while uncovering many technical details, has ultimately failed to unravel the complexity of this set of diseases (Weinberg, 2014). This is not an isolated incident - earlier this year, the biotech company Biogen halted two Phase 3 trials for its heralded Alzheimer's drug (Feuerstein, 2019), bringing up the debate of whether beta-amyloid, the hallmark of the disease, was actually a proper drug target; consequently, other theories of Alzheimer's disease progression (Begley, 2018) are currently gaining more traction. Cancer immunotherapy, widely acknowledged as a revolutionary breakthrough, is currently grappling with inexplicable phenomena such as diabetes in patients receiving IO therapy (Dolgin, 2019) and the low rate of response by patients (Haslam and Prasad, 2019). Most recently, off-target toxicity was found to be widespread among cancer drugs in ongoing clinical trials (Lin *et al.*, 2019).

These few instances are just the symptoms of a much larger crisis embroiling biomedical research and modern biology in general. The reproducibility crisis has been well documented in the past decade (Baker, 2016) and scientists are struggling to resolve that issue (Oransky and Marcus, 2017); a paper in 2011 showed that the higher the impact factor, the more number of retractions occur in a journal (Fang and Casadevall, 2011). The Precision Medicine initiatives undertaken both publicly and privately are failing to live up to their hype (Aelion *et al.*, 2016; Hasan, 2016a). Sham conferences and predatory journals have spawned at an alarming rate; current experimental strategies are guided by confirmation bias, an obsession with mechanistic details, genetic determinism, and investor relations rather than a proper theoretical framework (McHenry, 2008; Paganò, 2017; Maxmen and Warren, 2019). The absence of a proper theoretical framework has also resulted in abuse of statistical tests such as "p-hacking" (Head *et al.*, 2015) and the conflation of statistically "not significant" results with no biological effect or importance (Amrhein, Greenland and McShane, 2019; Montévil, 2019; Rubin, Schaeberle and Soto, 2019). The consequences of this epistemological crisis in biology are not limited to academia and are manifested in the econom-

ic, political and social landscapes as observed through the cases of Theranos (Fiala and Diamandis, 2019), the liquid biopsy company that promised the moon without any data, the bitter CRISPR patent battle (Ledford, 2017), the rise of eugenics under the guise of hyper-rationalism and the subsequent co-option of genetics by white supremacists (Hasan, 2019), the MIT-Epstein scandal (Farrow, 2019) and other high-profile incidences of conflict-of-interest between scientists and their work (Wadman, 2012; Glanz and Armendariz, 2017; Thomas and Ornstein, 2018), the exorbitant prices of drugs in the US that benefit only the pharma companies (Paton, 2019), the large turnover of startup biotech companies and a reduction of investment in R&D by big pharmas (Mazzucato, 2018), their increasing reliance on blockbuster drugs (Kresge and Lauerman, 2019) and insidious marketing strategies to create demand as exemplified by the Opioid Crisis (Keefe, 2017), an inflation of translational claims based on experiments with faulty pre-clinical models (Kaelin, 2017) and clinical trial endpoints that serve profit rather than patients (Kemp and Prasad, 2017), and much more.

The litany of what is currently wrong with biomedical research, or modern biology in general, is long but should not come as a surprise. After all, Levins and Lewontin (1985) had already pointed out

“Modern science is a product of capitalism. The economic foundation of modern science is the need for capitalists not only to expand horizontally into new regions, but to transform production, create new products, make production methods more profitable, and to do all this ahead of others who are doing the same. Its ideological underpinnings are congruent with these needs and also with the political philosophy of bourgeois revolution... The commoditization of science, then, is not a unique transformation but a natural part of capitalist development.”

The crisis in modern biology is then two sides of the same coin - the epistemological one, where reductionism reigns supreme with ad-hoc corollaries that fail to properly explain complex phenomena, is inherently tied to the practice of science under capitalism.

The entrenchment of capital and private interests in scientific research, a public good (Roy and Edwards, 2017), has been steadily increasing since the 1980s, as a result of a series of legislations that allowed for the patenting of “anything under the sun made by man”, followed by waves of privatization to boost translational research and public-private partnerships in the 90s, and further programs undertaken by state agencies in

the 2000s such as FDA’s Critical Path Initiative and NIH’s small business grants (Bouchard and Lemmens, 2008). However, more money has not resulted in better research - when NIH’s budget doubled between 1997-2003, the growth was observed mainly in ancillary markets such as reagent companies, expansion of universities, and number of NIH contractors (Pagano, 2017); ironically, a greater push for more private-public collaborations is offered as an answer to the money-product disconnect (Bertagnolli, Canetta and Nass, 2014).

What then is to be done? The solution to this crisis, both epistemological and practical, requires a radical shift in how biologists approach their work. In this essay, I will argue that theoretical practices grounded in the Marxist philosophy of dialectical materialism is poised to do so. Marxist philosophy, often restricted to the realms of political economy and sociology, nonetheless has a long history of enriching the natural sciences, not to mention that both Marx and Engels were influenced by Darwin’s theory of change in nature that they latter applied to describe changes in the social order. While a superficial understanding of Marxism can be dangerous, as seen in the case of Lysenkoism, a deeper understanding of dialectical materialism, especially the dialectics of nature, can solve the current epistemological crisis. This wouldn’t be the first time that Marxism would have rescued biology from a crisis: in 1931, at the Science at the Crossroads conference, BM Zavadovsky noted that the path to resolving the vitalism vs mechanism and reductionism vs mysticism debates lay in dialectical materialism, which went beyond the “attempts to embrace all the complexity and multifor-mity of the world through either a single mathematical formula of the mechanical movement of molecules or through the vitalist idea of a single ‘principle of perfection,’” (Sheehan, 2018). Similarly, on the question of the inheritance of acquired characteristics, as geneticists grouped themselves into Lamarckists vs Morganists, it was a dialectical understanding of genetics that Zavadovsky argued pointed towards Mendel and Morgan’s ideas (Ibid).

In the following sections, I will present a historical primer on the development of dialectical materialism as it pertains to natural sciences (dialectics of nature), present evidence from both historical and contemporary science that a dialectical framework is at the very least necessary starting point for unraveling modern biology’s present epistemological crisis in all its dimensions and, I argue, provides the tools for resolving that crisis.

## 2. A Primer on Dialectical Materialism

### 2.1 Hegel, Marx & Engels

The 19th century German philosopher G.W.F. Hegel revived the logical mechanism of ‘dialectics’ to understand the process of development, historical or metaphysical; for Hegel, dialectics was ‘the only true method’ of scientific and scholarly exposition, a method that ‘is in no way different from its object and content - for it is the content in itself, *the dialectic which it has in itself*, that moves out’ (Singer, 2001). The three-step Hegelian dialectic process (thesis, anti-thesis, synthesis) describes the opposing forces working against each other to produce a novel object or phenomenon can be used to understand the course of history or the development of thought. In *Philosophy of History*, Hegel used this logical mechanism to describe the political transformations that European societies underwent over centuries - from ancient Greek democracy as the thesis to the Reformation and the French Revolution as the anti-thesis, and lastly contemporary German society as the synthesis (Singer, 2001).

Hegelian dialectics, however, was too idealistic to describe the material world and man’s relation to it. This realization by Karl Marx and Friedrich Engels led them to re-work Hegelian dialectics to place matter in the center rather than the Idea. For Marx, “the idea is nothing else than the material world reflected by the human mind and translated into forms of thought.”<sup>1</sup> This key difference changed dialectics from an idealist to a materialist philosophy and where Marx broke with Hegel. Marx’s materialism stemmed from his study of Epicurus and Feuerbach, both of whose materialism he criticized to be too “contemplative”; for Marx, “we transform our relation to the world and transcend our alienation from it - creating our own distinctly human-natural relations- by acting, that is, through our material praxis” (Foster, 2000). However, Marx did internalize parts of Epicurean philosophy, which proposed that the movement of atoms was not entirely pre-determined but rather, some atoms “swerved”, which created the element of chance and indeterminacy (Ibid). Additionally, Epicurus also proposed a “principle of conservation” and rejected teleology and reductionism, both features which are key to understanding Marx’s dialectical materialism (Ibid).

<sup>1</sup> Capital. Vol I -1873 Afterword

Marx’s dialectical materialism was also inspired by his readings of Darwin’s theory of natural selection; in a letter to Friedrich Engels, he wrote “it is remarkable how Darwin recognizes among beasts and plants his English society with its division of labour, competition, opening up of new markets, ‘invention’, and the Malthusian ‘struggle for existence’” (Ibid). While Marx had realized that man’s relation to nature is dialectical, it was Engels who wrote down the three laws of dialectics of nature (Engels, 2012):

1. The law of the transformation of quantity into quality and vice versa.
2. The law of the interpenetration of the opposites.
3. The law of the negation of the negation.

Using these three laws to describe natural phenomena, Engels concluded that “in nature nothing takes place in isolation. Everything affects and is affected by every other thing” (Ibid). Engels’ natural worldview consisted of one in constant motion, where equilibrium existed due to contradictions and not as a steady state. What Engels was arguing for, as Sheehan (2018) describes, was “a developmental and integrative way of thinking grounded in a developmental and integrative ontology.” She also pointed out, however, that Engels’ use of Hegelian terminology created an array of “conceptual confusions” that affect Marxist discourse to this day, questioning the validity of the dialectics of nature.

### 2.2 The Dialectics of Nature Debate

Sheehan’s realization above had come from a series of debates on the nature of dialectical materialism that arose from Engels’s adoption of Hegelian terminology. In the early days of the Soviet Union, the line between scientists and philosophers were drawn along a *a priori* philosophy versus experimental science line. The experimentalists, or mechanists, accused the dialecticians of forcing Engels’s laws onto natural processes, whereas the dialecticians claimed that mechanists were unable to understand the reciprocity between theory and praxis. Nikolai Bukharin, in an effort to erase any residual Hegelianism from dialectical materialism, inadvertently adopted a mechanistic form of materialism while sacrificing the Epicurean materialism that left room for chance and indeterminacy. A version of this mechanistic materialism, as espoused by Lysenko, was later codified as the orthodox Marxist philosophy of nature by Stalin during his regime.

The core of the problem, as Sheehan argued, lay in the relationship between the natural sciences and

philosophy and how the history of the two were related in Marxist thought. In fact, it appears that the rejection of dialectics of nature by Western Marxists was partially inspired by the state of contemporary knowledge on natural processes. In *History and Class Consciousness*, György Lukács wrote on dialectical materialism that

It is of the first importance to realize that the method is limited here to the realms of history and society. The misunderstandings that arise from Engel's account of dialectics can be put down to the fact that Engels - following Hegel's mistaken lead - extended the method to also apply to nature. However, the crucial determinants of dialectics - the interaction of subject and object, the unity of theory and practice, the historical changes in the reality underlying the categories as the root causes of changes in thought, etc. - are absent from our knowledge of nature. (Lukács, 1972)

Going a step further, Alfred Schmidt distinguished between Marx and Engels' philosophies of nature on the basis of the question whether extra-human nature was also dictated by the laws of dialectics (Schmidt, 2013). Schmidt argued that "the concept of nature cannot be separated, in either philosophy or natural science, from the degree of power exercised by social practice over nature at any given time", thus echoing Lukács that dialectics are only applicable to nature through man's labour in relation to nature. In Schmidt's view, "it is only the process of knowing nature which can be dialectical, not nature itself." Schmidt also argued that by analyzing the findings of contemporary natural science using dialectical categories, Engels' dialectics of nature "remained external to its subject-matter". Schmidt thought that the dialectical process was incompatible with the scientific method since he considered the latter to be oriented towards formal logic and did not reflect the historical processes behind the objects. Consequently, the critical theorists and latter Western Marxists took on the neo-Hegelian position that dialectical materialism is only applicable for understanding social and historical changes and not natural phenomena.

### 2.3 Eco-Marxism and Man's Relation to Nature

More recently, drawing on Marx's early works such as the Paris Manuscripts and *Theses on Feuerbach*, eco-Marxists such as Foster and Burkett have pushed back against the critical theorists' rejection of dialectics of nature (Cassegård, 2017). In *Marx's Ecology* (2000), John Bellamy Foster argues that Marx had refused to

distinguish dialectical materialism from natural sciences and that Marxist philosophy was "predicated on the ultimate unity between nature and society". A similar assertion can also be found in Schmidt's writings (Schmidt, 2013), where he argues that both the early and the later Marx recognized that natural history was inseparable from social history, but precisely because of man's relation to nature through labor (admittedly, Foster shares similar views on human labour existing in a *metabolic* relation with nature).

Foster's arguments rely on the Epicurean materialism aspect of Marx's philosophy, and this is where he sees a break occurring between Engels' dialectics, which he deemed to be too mechanistic and deterministic. In his view, Marx's materialism extends beyond just "social praxis" to a "natural praxis" which incorporates an ecological perspective where the "biosphere constitutive of our own existence even as we transform it through our actions" (Foster, Clark and York, 2010).

At the kernel of the debate between eco-Marxists and the Frankfurt school Western Marxists then lies the relation between man and nature. Schmidt had outlined how the later Marx had concluded that man will never transcend their antagonistic relationship with the environment (an assertion that has later been used for a Baconian interpretation of Marxist philosophy) whereas Foster and eco-Marxists argue that the relation between man and nature is one of harmony.

In a critique of Foster's "natural praxis", Cassegård (2017) argues that nature is viewed as dialectical by Foster because it is the object of praxis. According to Cassegård, then, what is considered as a dialectics of nature actually is a dialectics of praxis *in relation* to nature. He criticizes Foster's dialectical analysis of evolutionary biology in support of 'natural praxis' as being still within the 'contemplative' realm, even when dialectics is used as a heuristic device. In an effort to reconcile the positions held by Schmidt and Foster et al, Cassegård invokes other critical theorists (Adorno, Marcuse, Horkheimer, etc.) to show that while "nature must remain a realm of necessity, does not mean that [human beings'] relation to nature must be one of perennial antagonism or domination."

The fact that science is a human enterprise then becomes a crucial point to assert the validity of Marxist dialectical materialism as a way to interpret our relation to the material world. The following sections outline the historical application of dialectics to biology and more recent developments that prove the validity of such application.



### 3. Dialectics & Biology

What is amazing is the similarity in the thinking of naturalists and dialectical materialists. The so-called dialectical world view is by and large also the world view of the naturalists, as opposed to that of the physicalists. (Mayr, 1997)

If Marx is considered to be the primary author of the new chapter on dialectics in Western philosophy, it can be said that Darwin fulfilled a similar role for materialism and natural science (Foster, 2000). Changes in natural phenomena, or natural history, upto the Enlightenment period was firmly in the hands of natural theologians, who considered nature to be teleological and governed according to laws set by a Supreme Being. It was Darwin's theory of natural selection, deeply rooted in philosophical materialism, that presented a radical break away from theological explanations of natural processes and moved the study of natural phenomena into the materialist realm.

Engels' laws of dialectics, influenced by Darwin's work, was taken up by Soviet scientists in various forms; a detailed analysis of such work can be found in Loren Graham's book *Science and Philosophy in the Soviet Union* (1972). But Soviet scientists were not the only ones adopting a dialectical framework to make sense of their findings - in the West, biologists such as JD Bernal, JBS Haldane, Joseph Needham, Marcel Prenant to name a few, were also applying the dialectical framework to understand biological phenomena and the practice of science to varying degrees. Bernal considered Marxist philosophy to be an extension of the scientific method and believed that "Marxism transforms science and gives it greater scope and significance" (Sheehan, 2018); according to Haldane, Marxism could be applied to understand the process of development of science and the history of science as a human activity. Needham, while unconvinced of the value of Marxism in ethics and politics, still believed dialectical materialism to be "the quintessence of scientific method," as "the natural methodology of science itself" (Ibid). Both Bernal and Needham insisted that dialectical materialism would be of great service to biologists by pointing the way towards the most promising hypotheses and by indicating which questions were meaningful and answerable.

How does Engels' laws of dialectics translate to a framework for biology? Ernst Mayr, in his essay *Roots of Dialectical Materialism* (1997), attempted to provide an answer - the first law is a principle of non-reductionism, the second is an explanation for the presence of energy

in nature that removes any sort of divine or external requirement and the third describes continuous changes in nature, i.e., evolution (Mayr, 1997). Therefore, dialectical materialism provides a theoretical bulwark against reductionism in biology as well as a framework to understand the changes underlying natural phenomena. However, the adoption of the Soviet interpretation by Western biologists presented a unique problem: the Soviet interpretation placed mechanistic materialism at the core of the dialectical framework and mechanistic materialism is inherently reductionist while under the dialectical framework, "biological phenomena, although historically connected with physicochemical phenomena, were not reducible to physicochemical laws" (Zavadovsky as quoted in Sheehan, 2018). In an effort to resolve this internal contradiction, Richard Levins and Richard Lewontin presented a variant of dialectical materialism that they believed was a "simultaneous negation of both mechanistic materialism and dialectical idealism" (Levins and Lewontin, 1985).

#### 3.1 Dialectical Biology

Levins and Lewontin applied dialectical materialism to biology, especially ecology and evolutionary biology, in an attempt to break away from the grip of Cartesianism which they deemed, along with contemporary dominant Western philosophy, inadequate to explain the complexities underlying large scale biological phenomena such as population ecology, evolutionary genetics, etc. They argued that the reductionism inherent in such philosophies undercut the importance of interactions between parts that made up the whole, ignored emergent properties, and forced science to choose separate causes for the same phenomenon. In their words, "where simple behaviors emerge out of complex interactions, reductionism takes that simplicity to deny the complexity; where the behaviour is bewilderingly complex, it reifies its own confusion into a denial of regularity" (Levins and Lewontin, 1985).

Using the dialectical framework and a host of evidence drawn from ecology and genetics, Levins and Lewontin proceeded to describe the interactions between genes, environment and the organism that results in the development of the organism, without ascribing causality to any single level of biological organization, and that these interactions, also termed "norms of reaction", should be the proper object of scientific investigation. Under this framework, development then

becomes a context-dependent open-ended process, similar to Alessandro Minelli's "disparity view" of development, which goes beyond the life cycle of the organism and extends to post-reproductive events like aging and pathological changes such as carcinogenesis; additionally, in Minelli's opinion, development may be reversible, not easily distinguishable from metabolism, not limited to adaptive traits and describe both permanent and temporal morphological changes (Minelli, 2014).

For Levins & Lewontin, the organism constitutes both the subject and the object of evolution, since the organism actively constructs its environment that in turn actively affects the development of the organism:

... an organism does not compute itself from its DNA.

The organism is the consequence of a historical process that goes on from the moment of conception until the moment of death; at every moment gene, environment, chance, and the organism as a whole are all participating... Natural selection is not a consequence of how well the organism solves a set of fixed problems posed by the environment; on the contrary, the environment and the organism actively codetermine each other.

They further argued that Darwin's theory of natural selection did not explain the origin of variation or that if selection resulted in differential reproduction of variants, then eventually there would not be any more variation for further evolution as a population would achieve uniform fitness. To resolve this contradiction, Levins & Lewontin proposed that Darwin's ideas can only reach full maturity when the organism is integrated with the "inner" and "outer" forces, as in the genotype and the environment, and viewed as both the subject and the object of evolution, as it is under dialectical materialism.

Lewontin went on to further solidify the necessity of using a dialectical approach to studying evolution and development of an organism. In his book *The Triple Helix* (2001), he writes "that the ontogeny [development] of an organism is the consequence of a unique interaction between the genes it carries, the temporal sequence of external environments through which it passes during its life, and random events of molecular interactions within individual cells. It is these interactions that must be incorporated into any proper account of how an organism is formed", thus establishing the organism as a site of interaction between the environment and genes (Lewontin, 2001). Therefore, under dialectical materialism, the long-running Nature vs. Nurture debate is

replaced by how Nature AND Nurture contribute to the development of an organism.

### 3.2 The Organism as the Holobiont

While Levins & Lewontin had largely applied the dialectical framework to biology above the individual organism level, Gilbert & Tauber (2016) did the same but at the individual organismal level to question what constituted biological individuality. Historically, an individual organism has been delineated by anatomical borders, functional integration through division of labour and communication between its parts, and a hierarchical system of control (Nyhart and Lidgard, 2011). However, using a host of scientific evidence that proves the ubiquity of symbiosis, Gilbert and Tauber argue that modern biology negates this notion of the individual organism; rather, organisms are "holobionts" - multi-genomic, composite organisms "whose physiology is a co-metabolism between the host and its microbiome, whose development is predicated upon signals derived from these commensal microorganisms, whose phenotype is predicated on microbial as well as host genes, and whose immune system recognizes these particular microbes as part of its "self" (Gilbert, Sapp and Tauber, 2012; McFall-Ngai *et al.*, 2013)." Gilbert & Tauber went on to show how dialectics exist at all levels of development of the holobiont - from fertilization (two cells fuse to become one) to organogenesis (stromal-epithelial interactions), the development of the immune system, symbiotic interactions between microbial and host cells, the construction of the ecological niche for the holobiont, and even down to the molecular level where stereo-specificity is determined by a set of interactions (induced fit model) rather than the deterministic "lock and key" model. Taking all these together, Gilbert & Tauber questioned the current conception of immunity as a defense mechanism and argued that immunology should be brought under the larger umbrella of ecology and proposed the field of "eco-immunology", since immunology has long been used to delineate the organism as a biological individual (Pradeu, 2010).

Eco-immunology, a complement to the "Eco-Evo-Devo" discipline (Gilbert, Bosch and Ledón-Rettig, 2015), is then used to understand the role of the immune system in the physiological and functional integration of the organism with its environment and dispels the binary notion of immunity being a defense mechanism. This is exemplified in the need for specific microbes for proper development of the brain, gut and reproductive

tissues across a host of animals (Hadfield, 2011; Sampson and Mazmanian, 2015). This idea, similar to Ilya Metchnikoff's idea that biological individuality was a result of the dynamic interactions among eukaryotic cells and between eukaryotic and symbiotic microbes then posits that the organism "was not a given, but rather a "work-in-progress" that underwent lifelong development in dialectical exchange with other potentially competing intra-organismal elements" (Gilbert and Tauber, 2016).

The organism as a holobiont is therefore the fruition of the application of a dialectical materialist framework to modern biology, and provides a novel way forward to continue doing so to unravel the complexities of natural phenomena. However, Western Marxists have long criticized such an application of the dialectics of nature - that it cannot be "arbitrarily foisted upon the world of nature from outside; that the dialectics of nature is an anthropomorphic projection of human concepts onto nature". But in *Dialectics of Nature*, Engels had clearly emphasized that there was no question that the laws of dialectics were **abstracted from** the history of nature and human society. In fact, he had already foreseen how biology was to be the fore-runner of a dialectical world-view in the sciences and that biologists would benefit from acquainting themselves with dialectical materialism. The main argument against the idea the dialectics is forced upon nature comes from Ernst Mayr's realization (quote at the beginning of the section) that naturalists and dialecticians share the same world-view. The two major developments in modern biology, as presented in the next sections, provides concrete evidence to Mayr's statement and validates Engels.

### 3.3 Neo-Lamarckism

With the rise of observations in developmental plasticity, it would appear that Lamarckian concepts of transmission of heritability are quickly gaining traction in Western science. While fetishism around the gene as the central identity has been the key ideology of the neo-Darwinians such as Richard Dawkins, and has propagated the DNA as the blueprint of life idea, neo-Lamarckian systems of transmission of inheritance as proposed by Eva Jablonka and Marion Lamb (1995) push back against this reductionist view of evolution. Jablonka and Lamb argue that short term evolution does not depend on new mutations in the DNA, but rather on epigenetic modifications that uncover genetic variants already present in the population. Additionally, genes undergo "shuffling" through recombination

during cell division, thus giving rise to further variation within the population. They also argue that the structure of the chromatin affects changes in the DNA sequence and therefore "highlights the complexity of the role of the environment in evolutionary change, the environment is not just the agent of selection. Through its effects on genes phenotype, it also biases the direction, rate and type of DNA changes at the locus", echoing Levins & Lewontin (1985). Jablonka and Lamb also propose group selection rather than individual selection, and counters the neo-Darwinian idea of the gene as the unit of selection by proposing groups of cells as units of selection instead (similar to Gilbert's holobiont concept) (Jablonka and Lamb, 1995). Cognizant of the fact that inheritance at the social and behavioral level are different compared to genetic and epigenetic level, Jablonka and Lamb (2014) describe four properties of Behavioral Inheritance Systems (BIS) that are founded on a fusion of collective-individual activity devoid of genetic hierarchy. They argue that

With variation transmitted by the symbolic system, there is a quantum leap in social complexity with families, professional groups, communities, states, and other groupings all influencing what is produced in art, commerce, religion and so on. Construction plays an enormous role in the production of variants, yet because symbolic systems are self-referential, the rules of the systems are powerful filters. The ability to use symbols also gives humans the important and unique ability to construct and transmit variants with the future in mind (Jablonka and Lamb, 2014)

In his analysis of evolutionary theory using dialectics, Julio Munõz-Rubio (2018) argues that this mechanism of inheritance is essentially a dialectical one since Jablonka and Lamb's work implies the evolutionary process to be a synthesis between the genetic information and the environmental influences, which Levins & Lewontin (1985) had described to be conceived as "two opposed, active, and mutually selective elements", thus forming "a dialectical *Aufhebung* of the organism-environment"(Munõz-Rubio, 2018).

### 3.4 Principles for a Theory of Organisms

Since the Molecular Biology revolution in the 1950s with Watson & Crick's discovery of the structure of DNA and the consequent establishment of Central Dogma of Molecular Biology, experimental biology has been steadily alienated from its theoretical counterpart. This is not to say that biological theories didn't

exist, but was rather abandoned as a storage of ideas from which to generate hypotheses. Increasingly, in the frenzy of “hypotheses-driven” science, aided by a genetic deterministic outlook and advanced sequencing techniques, there has appeared a reductionist science which fails to recognize the nascent contradictions between experiment and theory. A simpler version of this can be found in large genetic screen studies for complex diseases with the follow-up occurring only with a handful of genes, while at the same time the experiment is already biased by establishing a hypotheses *a priori* without a proper theoretical framework.

The scarcity of a proper biological theory of the organism, one which would be a complement to evolutionary theory but would describe the life cycle of the organism from conception to death, was recognized by the ORGANISM group (Soto, Longo and Noble, 2016). In an attempt to fulfill that absence, the group established three major principles that would serve as the basis for a theory of the organisms that would refute the dominant reductionist understanding of phenomena at multiple levels of biological organization. These principles were established on the basis of two important realizations - 1) there exists differences between inert and living that require separate theoretical development and 2) in biology, “ontogenesis and evolution are about relentless changes of symmetries, and the phase-space is being created along rather than set *a priori*” as compared to physics (Ibid). These realizations are also attempts to dispel the borrowing of theories from other fields, mainly physics, to explain biological phenomena, which has also resulted in the adoption of vernacular from information theory to describe biological interactions, such as “program” and “signaling”, with the implicit understanding that organisms are machines (Nicholson, 2013).

The principles for a theory of organisms are as follows (Soto, Longo, Miquel, *et al.*, 2016) -

1. A principle of biological inertia: the ‘default state’ of proliferation with variation and motility.
2. A principle of variation that accounts for the emergence of novelty through development and evolution
3. A principle of organization that accounts for the stability of organisms.

These principles present a radical transformation for experimental biology - attributing the organism with the ability to create their own “norms” (Ibid) shifts the view from the organism from being a passive agent of change, as articulated by findings from *in vitro* tissue culture studies over the decades, to one where the

organism’s default state is constrained by the environment; in fact, as both theoretical and experimental studies show, organisms act on their environments to create constraints on their own mobility and proliferation and therefore results in organization (Barnes *et al.*, 2014; Montévil *et al.*, 2016). In fact, these principles are able to resolve long-standing confusions within the cancer research field - the Tissue Organization Field Theory (TOFT) that posits the default state of cell as proliferation with variation and motility and that cancer is a tissue-based disease, along with the principle of organization, shows that carcinogenesis arises from the disruption of interactions between the stromal and epithelial compartments of the tissue (Sonnenschein and Soto, 2016). TOFT also provides explanation for emergent properties observed within carcinogenesis, which the dominant reductionist Somatic Mutation Theory (SMT) is unable to (recall Weinberg’s admittance in the Introduction section) (Soto and Sonnenschein, 2005).

Although the derivation of these three principles are separate, it is abundantly clear that the laws of dialectics can be abstracted from these principles and their use. At first glance, it is obvious that these principles and dialectics both share the anti-reductionist nature, and stress on the importance of interactions between the organism and its environment, and among the multiple levels of biological organization. Both Hegelian dialectics (thesis, anti-thesis and synthesis) and Engels’ dialectics of nature are in concordance with these principles - the “incessant breaking of symmetries” (Longo and Soto, 2016) by organisms can be viewed as a constant flow of thesis, anti-thesis and synthesis; Engels’ dialectics of nature, a la Levins & Lewontin and Gilbert & Tauber, is also observed within the applications of these principles to biological phenomena - the first law is exemplified by phase-space changes and symmetry-breaking, the second law is manifested in TOFT and the third law in the negative control of cell proliferation that is based on the default state (Soto, Longo, Montévil, *et al.*, 2016).

## 4. Towards a Radical Science

It is important to emphasize that the way science is is not how it has to be, that its present structure is not imposed by nature but by capitalism, and that it is not necessary to emulate this system of doing science. (Levins and Lewontin, 1985)

The above evidence presented from biologists make it clear that contrary to forcing dialectics on nature, it appears that biologists have developed similar fra-



meworks (systems biology, the pluralistic extension of evolutionary theory, and the principles for a theory of organisms) to understand complex phenomena. This realization might raise the question of whether Marxist philosophy is actually needed to resolve the crisis in modern biology. The answer to that, in my opinion, is a resounding yes, precisely because a key tenet of Marxism is missing from science. While parallel developments have been made in the epistemological arena, the practice of science severely lacks any understanding of labour and the process of production. Science is still very much in the grips of the capitalist mode of production, and the bourgeois philosophy that guides the research paradigms cannot be separated from the bourgeois practice of science.

#### 4.1 Lysenkoism and Marxist Biology

A discourse in Marxist biology is incomplete without any reference to Lysenkoism, a particular set of agricultural practices and scientific ideas of heredity based on Trofim Lysenko's understanding of dialectics of nature. However, while Lysenko's science may have been dubious (Gordin, 2012), it should be noted that Lysenkoism represents the confluence of political, economic and scientific factors that led to the controversial ideas about genetics and subsequent applications in agriculture during Stalin's regime in the Soviet Union (Levins and Lewontin, 1985; Clark and York, 2005; Gordin, 2012; Sheehan, 2018). The political aspects of Lysenko's meteoric rise to power in Stalin's government is described elsewhere and not the focus of this section.

Lysenko's proposed theory of heredity ignored the existence of genes (but did acknowledge the existence of chromosomes), and posited that heredity was based solely on the interaction between environment and the organism, and therefore intentional changes to the environment can direct organismal growth. In this formulation, however, the organism becomes the passive object of change rather than an active agent. Moreover, the codification of Engels' dialectics of nature, as viewed by Lysenko and his followers, removed any possibility of chance as an ontological property (Levins and Lewontin, 1985). But as explained above, Marx's dialectical materialism based on Epicurean materialism, included chance as an ontological property. Therefore, Lysenkoism did not fully represent Marxist philosophy, and became the "vulgar Marxism" that it had sought to abolish in the natural sciences. It is then quite unfortunate that Lysenkoism continues to be held up by the

West as Marxist science (Kean, 2017) when it actually went against the tenets of Marxist philosophy which advocates for unity of structure and process, and the wholeness of things based on interactions of its parts. It should be noted that the resurgence of Lysenkoism in Russia in the last two decades have been not because of a better understanding of Marxist philosophy, but rather a confluence of geopolitics, anti-science sentiments and scientists who, with the advent of epigenetics, trying to rehabilitate Lysenko (Kolchinsky *et al.*, 2017). However, as pointed out above and also by Kolchinsky *et al.* (2017), the problem with Lysenkoism lies at the ideological level, but not due to the incorporation of ideology in the sciences.

Considering the evidence presented above, it can be concluded that biologists have arrived at a very similar view of organism, environment and natural history as dialectical materialists had proposed. In some way Lukács was right - the contemporary knowledge was not sufficient to validate Engels' dialectics of nature; but he was also wrong in concluding that therefore Engels' laws are unusable for understanding our natural world. The resolution of the crisis in modern biology cannot be achieved just through introduction of theories. As Bernal concluded after his analysis of scientific practice under both capitalism and socialism, the crisis in science is an "inescapable feature of the capitalist mode of production" (Sheehan, 2018). Similar sentiments have been echoed by later scientists, whether they identified as Marxist or not. The common theme between them was the realization that scientific practice is not ideologically neutral, and the analysis of science under capitalism has shown a widespread "abuse" of science historically (Rose and Rose, 1972).

It's not only scientists that realized the heart of the problem lay in the bourgeois practice of science. The British Marxist Christopher Caudwell (born St. John Spriggs), argued that the conflicts in biology was due to the dualistic nature of bourgeois culture itself and the resolution of the conflicts lay in breaking out of it.

#### 4.2 A Science for the People

Current science is considered to be apolitical and rational, and free of value judgement. This illusion, created by decades of entrenchment of bourgeois philosophy, especially after the disastrous effects of Lysenkoism, has quietly transformed scientists and trainees into the "biomedical workforce", a proletarianization of scientists to speak (Levins and Lewontin, 1985; Lazeb-

nik, 2015). In contemporary society, scientists occupy what has been termed as the professional-managerial class (PMC; Press, 2019) that exists between the working and the ruling class. Historically, while the PMC has understood the necessities of the working class, their allegiance has unfortunately been with the ruling class (Winant, 2019). Considering that biomedical researchers are increasingly encouraged to become entrepreneurs (one only needs to look at the number of startups on university research campuses), it is understandable how the ruling class stands to benefit from maintaining the distinction between the PMC and the working class (trainees, staff, custodial workers, etc). A quick look at the state of academics in the US universities reveal that while some academics may enjoy a greater status and income in this current capitalist order, the majority of the biomedical and scientific research workforce are getting squeezed harder and harder. Tenured and adjunct faculty (Hasan, 2016b; Birmingham, 2017), graduate students (Academics Anonymous, 2018) and postdocs (Nature Editorial, 2018), and even undergraduate students (in the form of skyrocketing tuition costs; Maldonado, 2018) are all exploited for their labor as they face more and more restrictions on their rights as workers as universities relentlessly pursue capital accumulation. This exploitation has resulted in a mental health crisis (Flaherty, 2018) among graduate students, and threatens the productivity or the state of research altogether. At the same time, the US universities are experiencing an administrative bloat (Tufts Daily Editorial, 2017) with increasing salaries for university presidents (Bauman, Davis and O’Leary, 2019).

The steady neoliberalization of universities (Seal, 2018) also coincide with the alienation of theory and practice within science, in an effort to remove any ideological influence. Unsurprisingly, considering the socio-political history of capitalism, science has historically been used to uphold the *status quo* of the bourgeoisie, regardless of the outright racist, sexist, oppressive and other discriminatory consequences, and will continue to do so unless the grip of bourgeois culture has been broken in scientific research. While liberal critique of science sees instances such as the Tuskegee syphilis experiment and sociobiology as isolated incidents of abuse of science, this reductionist interpretation fails to incorporate a historical analysis, which again points to the need for a Marxist philosophy in the practice of science. Early attempts to create a proletarian science, such as Bogdanov’s Proletkult in the Soviet Union or collectivization of scientific workers in the US in the

form of workers unions, did not survive the changes in the political landscape for various reasons.

In writing for the revitalized *Science for the People* magazine, Helen Zhao (2019) discusses how science, both theory and praxis, can be radicalized and what the movement’s goals should be. Reviewing the comments from a host of scientists-activists, she asks “where do the ‘experts’ and ‘expertise’ belong - if anywhere - in a science emancipated, a science for the people (Zhao, 2019)?” The answer can be found in Caudwell’s formulation of proletarian science, as described by Sheehan (2018),

For Caudwell, proletarian science was the integration of sciences (...) within an integrated world view. Caudwell said quite firmly that it was not a matter of imposing the dictatorship of the proletariat on science. It was not a matter of the honest worker telling the scientist what was what in his laboratory or in his theory. Nothing was to be imposed on science. Nothing was to be imposed on the scientist, not even by himself. It was a matter of assimilation of the scientist to the cause of the proletariat, to the construction of a new society in which he played his full part within the process and as a scientist. Science was to be developed by scientists, but a new type of scientist, with his feet more firmly on the ground, with his mind more opened to the whole, with his life and work more organically connected to the society of which he formed a part.

## 5. Conclusion

The evidence presented above supports the proposal that Marxist philosophy of dialectical materialism, is poised to provide a resolution to this crisis. The application of dialectics has been observed at key stages of theoretical development in modern biology, and can be further used a heuristic device alongside the ORGANISM group’s principles for a theory of organisms, Jablonka and Lamb’s evolutionary theory, Gilbert and Tauber’s concept of the holobiont as the biological individual, and Minelli’s theory of development. However, science does not exist in isolation and only Marxist philosophy can guide the transformation required in the practice of science that is required to break out of the clutches of bourgeois culture and philosophy. Therefore, the crisis cannot be resolved unless there is unity between theory and praxis, as Marx proclaimed “philosophers have hitherto only interpreted the world in various ways; the point is to change it.”<sup>2</sup>

<sup>2</sup> Eleventh thesis on Feuerbach (1845)

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