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Friedrich Engels' Importance for Contemporary Materialist Epistemology*

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ABSTRACT: In this contribution for Friedrich Engels' bicentennial birthday, we investigate to what extent the epistemological ideas of F. Engels, based in nineteenth-century science, can serve as stepping stones towards a novel materialistic epistemology given de contemporary state of the sciences. I look at Engels as an historical figure in his nineteenth-century context with strong and pertinent emancipatory ideas, who understood the need of a materialistic epistemology for the emancipatory project he and Karl Marx envisioned. In this contribution I will focus especially on his *Anti-Dühring* and his *Dialectics of Nature*, in their nineteenth-century context. Secondly, I will use his intensions in writing these inspirational works as a basis for further reflections on the sciences and their possible contribution to human emancipation. In particular, I will touch upon the issue of to what extent scientific theories represent the known world and to what extent theories in the natural sciences and biology can serve as a model for the humanities and sociology. In other words, if we consider the world materialistically, that is to say, it exists independently of what the human race as offspring of this world makes of it, how can the early inroads of Engels and Marx in making this world intelligible, help us today in rescuing humankind from self-inflicted disaster.

KEYWORDS: F. Engels, materialism, science, biology, human nature.

Nowadays it is no longer a question of combating an idealism that denies science, but rather of combating an idealism within modern science. This struggle entails: upholding a materialist epistemology as against either Platonist-theoreticist or empiricist-agnostic conceptions of science prevailing today; rejecting the antithesis science-history (something not done with sufficient clarity by the anti-historicists), and placing the historical sciences of nature and their consolidation with the human sciences at the centre of the discussion; and, finally, elaborating on the link between materialism and hedonism, with all the consequences it has for the model of the socialism we envisage for ourselves. Anti-Engelsism represents a rejection of that outlook. (Timpanaro 1975a, 128)

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1. THE CHALLENGE

A commemoration of a hero like Friedrich Engels should be more than a review of all his words and deeds. Many biographies have been written, hagiographical as well as hateful. Unfortunately, both literary genres are of limited value if we want to address Engels' merits in stimulating us, here and now, to develop a contemporary materialistic epistemology, void of the semi-religious overtones that could be observed during the Stalinist cult.

The time seems to be right for a new approach to Engels, which does away with old mystifications. Such an approach can build on the excellent edition of Engels' writings in the *Marx-Engels Gesamtausgabe* (*MEGA*²) and their excellent introductory essays which explain the works and situate them in their nineteenth-century context (Engels 1985; Engels 1988).

Engels was often caricatured. This might have been grounded in the perceived unilineal succession of Marx, Engels, Lenin, Stalin and Mao. Critics of this suggestion often work backwards and in 'rescuing' Marx make Engels the culprit. He has often been depicted as a great simplifier who distorted Marx's subtle and brilliant ideas (Levine 1975; Carver 1983). In the mid-1970s, Sebastiano Timpanaro forcefully attacked the artificial and unsubstantiated role of Engels as the bad guy: "During the twentieth century, each time that a particular intellectual current has taken the upper hand in bourgeois culture [...] certain Marxists have attempted to 'interpret' Marx's thought in such a way as to make it as homogeneous as possible with the predominant philosophy" (Timpanaro 1975a, 73). "Thus, whereas Engels is loaded down with materialist ballast, Marx can take on that physiognomy of a profound and subtle (and still uncomprehended) great intellectual which is *de rigueur* in our cultural world" (ibid. 74).

In the same vein, two more recent books stand out. Elmar Altvater (2015) stresses the unity of nature and society and critically discusses Engels' critics and emphasises his anticipation of much of present day discussion of ecology. Michael Krätke (2020) emphasises the intimate intellectual and practical collaboration between Engels and Karl Marx as well as Engels' role as initiator of novel ideas and concepts. We find a timely critique of "Engels Bashing" as Krätke refers to it. Historical distortions can only be avoided if we situate a thinker in his or her historical context. We can never define a person's strivings and quests as improper, divergent, or even false without taking the whole historical societal context and its contingences (e.g., religion, political oppressive culture, morals, etc.) into account. The only thing we can declare is that any theory is provisional and

is always up for review and surpassing. Sometimes its lifespan is short (as in the case of the phlogiston theory in chemistry), and sometimes it lasts for a very long time (such as the notion of absolute space). The historicity of theory is by and in itself dialectical, and dialectics means transcending stages. Historical materialism intrinsically means self-reflection; the productive forces change society and *vice versa*: the history of Marxist theory has to be written in a Marxist way. The notion of historical contingencies is still ill-defined in its broad economic, political, biological and physiochemical sense. Historical materialism is an analytic approach with its own dynamics and can certainly not be reduced to supposedly more fundamental notions such as dialectic-materialism (Diamat), as posited in the Stalinist school, nor as unmediated superstructural "reflections" of the materialist base (as in vulgar materialism).

Historical materialistic self-reflection is an expression of human labour and as Karl Marx wrote in his second thesis on Feuerbach:

> The question whether objective truth can be attributed to human thinking is not a question of theory but is a practical question. Man must prove the truth, i.e., the reality and power, the this-worldliness of his thinking in practice. The dispute over the reality or non-reality of thinking which is isolated from practice is a purely scholastic question. (Marx 1976b, 3)

This is a clear call for serious scientific investigations on all aspects of humankind.

Engels therefore has to be situated in *his* context with its related contingencies. In line with new developments in the historiography of science, it may be helpful to analyse Engels as a *persona*. Lorraine Daston and Otto Sibum, who develop this concept in the context of social studies of science, wrote: "Intermediate between the individual biography and the social institution lies the persona: a cultural identity that simultaneously shapes the individual in body and mind and creates a collective with a shared and recognizable physiognomy"(Daston and Sibum 2003, 2), and "[...], the interaction between the society that must grant significance to a persona and the individuals who must embody it occupies center stage, underlining the hybrid character of the persona concept between individual and society. Symbols, values, and meanings—the stuff of culture—are essential components in this interaction". (ibid., 7).

I will try to advance the discussion on Engels, on why, whence, and what he wrote, and moreover on the question of how, today, we can pursue Engels' fundamental quests, in the context of our present understanding of humanity as part of nature. I will attempt two things.

First, I will try to develop the foundations for a historical-materialist interpretation of Engels' historical materialism, focusing especially on his *Anti-Dühring* and his *Dialectics of Nature*. Secondly, I will use these inspirational works as a basis for further reflection on the sciences and their possible contribution to human emancipation in the contemporary world.

2. ENGELS IN PERSPECTIVE

Four Necessary Questions

With the hindsight of two centuries we have to address at least four issues.

First: what was Engels' political and moral motivation? Why did he try to develop a theory and practice for the emancipation of humankind—from the abolition of the various forms of oppression to a novel form of society in which everybody works (with pleasure!) according to his/her capacities and receives goods and shelter according to her/his needs? And, how did Engels express this motivation in his cultural context and the concrete societal contingencies of his time?

Secondly: to what extent was the way in which Engels framed his emancipatory political project influenced by the hegemonic culture of mechanistic thinking and by the phenomenal explosion of biological, chemical, agricultural, geological, and physical theories, as well as their applications in technology? To what extent did this hegemonic culture shape his view on social movements as emancipatory projects?

Thirdly: How do we, today, incorporate new scientific insights and new models into the emancipatory project without trying to mould all novel knowledge and understanding into old schemes? Essential here is: how we can peek better—even if it is only a tiny bit—into the future. In other words, how are twenty and twenty-first-century scientific accomplishments inducing changes in our vision of a possible future? Karl Marx took as a fundamental human feature the uniqueness of the human species in its capability of teleology:

> Man not only effects a change of form in the materials of nature; he also realizes [*verwirklicht*] his own purpose in those materials. And this is a purpose he is conscious of, it determines the mode of his activity with the rigidity of a law, and he must subordinate his will to it. (Marx 1976a, 284)

Marx here expresses also a typical nineteenth-century belief in everlasting laws, with predictable outcome, a notion which must be left behind. However, a better world is not a fixed object in itself. We simply have no idea what the societal tensions will be in a post-capitalistic society, even with

deep knowledge of failed experiments in the USSR, China, Cuba and many minor other projects.

Fourthly: how can we, on the basis of preliminary answers to the first three questions, consciously advance the better future Engels was striving for—not only through a struggle against capitalist exploitation and other forms of oppression, but also by clarifying possible roads to be taken? Such a project must be framed in terms of the tension between hopes for the future and the concrete potentialities of the present. An epistemology for the Anthropocene, forcefully demanded by Jürgen Renn, is an integration and transcendence of older phases of human culture and knowledge (Renn 2020).

The present contribution is restricted to Engels' (and Marx's!) tacit assumption that modern science could be a model and engine for emancipation. After all, in their fight against the utopians they coined the term scientific socialism in a period of explosive developments in all natural sciences. What did the limits of nineteenth-century thinking mean for their project? What do recent theories and models reveal about the (im)possibility of defining our point on the horizon? In other words, how is the historical contingency changing? Equality for all human beings within the notion of "according to capacities and needs" does not mean that people are equal as atoms as rational choice theory in neoclassical economics claims, which is based on nineteenth-century thermodynamics (Mirowski 1991). We know people are all different and now even economists accept that.[1]

The Anti-Dühring Context

The successes of the nineteenth-century sciences as: thermodynamics, electromagnetism, organic chemistry, geology, and emerging genetics in the form of evolution and heredity, filled the world with optimism and the idea emerged that, if "correctly" applied, humanity would overcome war and misery. This scientistic optimism was a strong impetus for the idea that socialism must be based on solid theory and henceforward socialism will be able to overcome, in an organized way, the Hobbesian war of all against all. Whilst Marx and Engels tried to create a scientific socialism, it

1. Interestingly, even two Sveriges Riksbank Prizes in Economic Sciences in Memory of Alfred Nobel are bestowed to people who gently prod rational choice theory; Daniel Kahneman (2002): "for having integrated insights from psychological research into economic science, especially concerning human judgment and decision-making under uncertainty": and Richard H. Thaler (2017): "for his contributions to behavioural economics."

was also a common and firmly-held belief that the organisation of society must be based on a conscious plan and that such a plan could be hammered out by proper use of science and technology.[2]

As Griese and Pawelzig, both members of the editorial team of the Mega[2] publication of *Dialectics of Nature*, point out, in the early workers' movement the necessity of a broad education (*Bildung*) was an important aspect of political activity. Engels' extensive comments on Dühring are in line with that view. The authors argue also that Engels' notes that became *Dialectics of Nature* must be seen in that context. Engels' ambition was not so much a new theory, such as Marx's project on economy, but to offer a wide ranging overview proving the need for a "scientific" social theory, contra forms of simplistic materialism *a la* Ludwig Büchner (Griese and Pawelzig 1995).

Eugen Karl Dühring was a brilliant ideologue, anti-Semite and precursor of National Socialism (Kaltenbrunner 1970), with a substantial influence in the young German social democratic movement. He published within a very short time span a series of books ranging from titles such as *Kapital und Arbeit* (1865), and ultimately his pre-fascist book *Die Judenfrage als Racen-, Sitten- und Culturfrage mit einer weltgeschichtlichen Antwort* (1881) (Muller 2004).

Against opportunism and romantic pipe-dreams in the early workers' movement, Engels set out to define "scientific socialism" as a way to systematically develop socialist theory. Dühring's works became a pretext to systematise socialist thinking; "On the one hand it gave me, in connection with the very diverse subjects to be touched on here, the opportunity of setting forth in a positive form my views on controversial issues which are today of quite general scientific or practical interest" (Engels 2010a, 6).

Engels, with Marx's active assistance, wrote a monumental *tour d'horizon* in a very short period of time. As he explains in the preface of the 1st edition "The following work is by no means the fruit of any 'inner urge'. On the contrary" (ibid., 5), which indicates that the work is not structured as an independent treatise on socialism. However, its polemical attack on Dühring had a distinct educational purpose.

Engels' *Herrn Eugen Dührings Umwälzung der Wissenschaft or Herr Eugen Dühring's Revolution in Science* (often shorted to *Anti-Dühring*) became after its third edition of 1894, a foundational and central textbook on historical

2. Interestingly, in the anthology *K. Marx, F. Engels, V. I. Lenin, On scientific Communism,* not one reference to any science is mentioned in the 500 plus pages (Marx, Engels, and Lenin 1967).

materialism and dialectics for generations of socialists worldwide. Obviously, it is quite easy to attack this book on the bases of later political experiences and accumulated knowledge.

The real issue is not *Anti-Dühring*'s many hand-waving examples or insufficiently well-researched technical subjects, but the fact that such a strong polemic and historical contextual educational book became a bible for the social democratic movement and even a holy scripture in the Stalinist cult. This in complete contradistinction to Engels' emphasis on self-organization and self-emancipation. Engels' many arguments by example, instead of being built-up from underlying dynamics, served an educational role. However, in later years, and in particular in Diamat (the Stalinist nickname for Dialectical Materialism), an inversion took place from examples revealing dynamics, to laws determining dynamics. Similarly, mathematical or logical laws became leading forms of thought. The three so-called dialectal laws (the unity of oppositions, the negation of the negation, and the quantity-quality transition) abstracted from (historical) empirical investigations, became grounding concepts considered as ultimate truths, like the idea of Euclidian geometry.[3] We read in *Anti-Dühring* and *Dialectics of Nature* an attempt to concretise Hegel's not always exact formulations: e.g., Hegel never stipulated 'laws' but more tendencies. As Marx said:

> The mystification which the dialectic suffers in Hegel's hands by no means prevents him from being the first to present its general forms of motion in a comprehensive and conscious manner. With him it is standing on its head. It must be inverted, in order to discover the rational kernel within the mystical shell. (Marx 1976a, 103)

In other words: we have to make the dialectics operational.

Interpenetrating objects, forces, movements and concepts will because of their historical dynamics always be re-expressed in novel models. Laws, phrased in human (sign) language, are human expressions of experience and knowledge and hence never trans-historical. This in contradistinction with human inventions, which emerge in a historical setting but remain (not necessarily in use) with us, such as the bike, the atomic bomb, or a mathematical theory (*pace* the Platonists).

The very fact that the nickname of the book is *Anti-Dühring*, is already a strong warning that the book is an attack, and not the first instalment of a book series under the title *Pro-Socialism*. It would honour Dr. Dühring too

3. It goes without saying that putting laws as primary, opens the gates for structuralism.

much to take his works as a starting point for an *ex negative* definition of socialism.[4]

Experimental Knowledge

So what does this mean for a fresh approach? Not that we have to start at the dawn of human civilisation, no more than Marx's analysis of say the economy of the Babylonians is crucial for his critique of the dynamics of modern capitalism. We should not try to press a "law" onto history which consequently must lead to a well-defined future. The nineteenth-century notion of physical law became a model for "natural" societal laws, and such a powerful one that it needed Rosa Luxemburg's revelation (instead of an obvious conclusion) that the capitalist mode of production does not have to end in socialism, but may as well end in barbarism: the total destruction of nature's evolutionary experiment with humanity (Luxemburg 1915).[5]

Engels' attack in *Anti-Dühring*, and his notes in *Dialectics of Nature* are embryonic pieces for a larger and different work on how we understand nature and the methods and technical devices for interacting with nature. For a contemporary reader it is important to read through the polemics and try to understand the deeper reasoning. Engels had a remarkably broad knowledge of the sciences and biology of his time. But we have to take into account that this knowledge was not always the latest and hottest, and was sometimes even severely lagging behind, as in the case of mathematics, as the erstwhile secretary of Trotsky and later famous mathematician Jean van Heijenoort angrily wrote (Van Heijenoort 1985). Furthermore, just because *Anti-Dühring* is polemical, its arguments are often grounded in examples and not based (yet) on a consistent theory.[6]

The notes that Engels penned, beginning even before writing *Anti-Dühring*, contain interesting considerations but are certainly not worked-out thoughts. We can safely quote Albert Einstein, who as requested by

4. It always strikes me as a typical Germanophobe Anglo-Saxonism that the German title Herr, which simply means mister or Sir, is never translated. Just watch any UK film or (TV) play in which an unpleasant German citizen appears, it is always Herr X and not mister or Sir X.
5. For an interesting discussion on the true Kautskyan origin of the of the slogan 'socialism or barbarism' see Angus 2014.
6. The same we witness in many political tracts: "we see (examples of) the misery, the oppression and the devastation, for which capitalism is to blame, hence we have to topple the system and build a new one". However, unfortunately, most of the time with less marching routes than moral calls for solidarity and action.

Eduard Bernstein, in reviewing part of the notes which became *Dialectics of Nature* wrote:

> [...] the content is of no particular interest either from the point of view of contemporary physics or for the history of physics. On the other hand, I can imagine that this text might be considered for publication insofar as it makes an interesting contribution illuminating Engels' intellectual personality. (Engels 1985, 597)[7]

The real discussion then and now is not about the examples that inductively prove a worldview (*Weltanchauung*), but about how we can understand the historicity of nature and the fact that the planet is one whole, one totality. We now deal with a catalogue of mutually exclusive theories and their regulatory laws,[8] but progressively we must reach an encompassing understanding of the dynamics of nature and the role of humankind therein.[9] The crux is: how the human body as biological matter is able to reflect all her experiences in ever newer theories, spanning ever more fields of investigation. It is in the nineteenth century that we see the monumental steps forward in all sciences. This is why Engels gives considerable attention to these new developments.

> Philosophical respectively dialectical thinking was for Engels—and here he agreed with Hegel and not with Schelling—thinking based on concepts, conclusions and proofs. It is in this sense scientific thinking. Only on this premise, philosophical thinking may claim the knowledge process of the natural sciences. (Griese et al. 1985, 32*)

"A large part of the present manuscript [*Dialectics of Nature* - JK] is devoted to the questions of how far the objective dialectic of nature is reflected in the natural sciences, and how far they have a dialectical content" (ibid., 49*). Here, the problem is well posed. If we start with the notion that Nature is a dynamic system in which temporal structures and forces mutually interact, then we realise that we are confronted with a temporal development. In our present (earth-bound) case, we reach the limits of traditional thinking and models. Engels, just like many philosophers, takes the latest

7. A full history of the publication of Dialectics *of Nature* is given in (Engels 1985).
8. Such as Newtonian mechanics, Quantum mechanics, and General relativity theory, which have three distinctly different notions of space, time and space-time.
9. This general idea of unification is not particular to Engels, but an age old longing, at least in physical sciences. In a way, this aspiration for a unifying theory, and preferred semantics, can be seen on a par with monotheistic thinking.

versions of "natural" laws as the starting point for projections into the future.[10]

Engels is "scientific" as he stresses that nature intrinsically expresses herself in, what we call, dialectics, which is a good working hypothesis. Just as Euclidean geometry is an excellent hypothesis, as long as we have no other intuition for interpenetrating mutually determining phenomena, other than renaming it as say non-linear behaviour. The transcendence of limits in our thinking and modelling is expressed in the fact that we witness regular overhauls of scientific theories.

Engels spends a lot of pages on the simple example of chemistry. Dialectics in chemistry, which comprises a big chunk of the notes, is relatively easy to grasp. As soon as it became clear that we can consider chemical molecules as being composed of a number of more elementary chemical atoms, this decomposition of the molecule demanded a theory of the various forms of chemical binding. Combinations of individual entities, be it atoms or molecules, cannot exist without the notion of binding. In superficial language one might say that the particle (an atom, molecule, or subatomic entity) and its binding forces are a composite totality, as the new, bounded, particle is again a self-contained unit. Thinking that way, one might call the intertwined opposition of chemical atoms and binding forces a dialectical unit, as chemical molecules are thought of as being objects with a limited spatial extension and binding forces are considered as fields which reach over long distances compared to the size of the atoms, this whilst they only exist together.

It goes without saying that the theory of chemical binding turned out to be tremendously successful and found equivalents in theories about the composition of elementary particles, the constituents of atoms. They all fit the notion of a world composed of particles and fields, to be later transcended into the idea that also particles can be described by (matter) fields. The opposition between particle and force fields is then "solved" by quantum field theory. The quantity-quality law in chemistry can easily be illustrated in the case of the homological chain of organic molecules where adding one carbon atom to the chain, changes the character of the molecule fundamentally.

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10. Look at, for instance, the New Age and later post-modern interpretations of quantum mechanics. It is beyond the present work to expand on the once-heated discussions on the so-called "Sokal hoax" and the subsequent "Science wars" in the 1990s, as the antagonism between the scientist and post-modernists are not that simple and straight forward.

However, the question is to what extent this picture is an expression of an innate dialectics of nature or only a human approximation of the supposed dialectics of nature? Is dialectics our way of understanding the fact that "objects" are never isolated?

Formalized Knowledge

The situation becomes different if we don't start with experimental knowledge, but with theoretical models, such as in mathematics.

Mathematics is the art of thinking that has only two rules: rigour and consistency. Everybody is free to define any mathematical object and any mathematical rule, as long as the resulting theoretical construction based on these well-defined starting points is internally consistent. The fantastic fact is that some mathematical approaches turn out to be excellent tools for describing e.g., physical phenomena and physics applications. But the pertinent and often posed question; why mathematics is so effective, is fundamentally a-historical and undialectical (Wigner 1960). Over the centuries, effective modelling emerged as a result of social collective labour. If a model works it looks (for the moment) like a miracle. Human mental labour created the tin-opener as well as set and manifold theory and if we forget this, indeed by opening the tin, the resulting sardines in tomato sauce looks like coming from heaven.

In mathematics only rigour and consistency count and we are allowed to build any theoretical skyscraper we like, as long as the basic notions and the rules are well defined. Therefore, the claim that mathematics fits perfectly into Diamat is questionable. For example, the eminent Soviet mathematician Aleksandr Danilovich Aleksandrov, Lenin order and Stalin premium prize winner, has argued that differential geometry transcends the opposition between discrete entities and a continuum. The caveat of the intrinsic dialectical demand that the new situation can be negated again is not addressed. Aleksandrov's writings are a defence of, what he sees as an intrinsic dialectics of mathematics, in a highly political philosophical debate, (Aleksandrov 1970, 1971, 1980).

Coming back to Engels, we experience his weakness in mathematics in his discussions on the square root of minus one: sqr(−1), or $\sqrt{-1}$, which is defined as the sign "i", which means i squared equals minus one. Engels simply did not understand the importance of complex numbers (numbers including a so-called "imaginary" part: a multitude of "i"), which got full currency in the nineteenth century. Instead of depicting a number on a one

dimensional line, a two dimensional coordinate system turns out productive to represent complex numbers. Nowadays also quaternions (four axes) and octonions (eight axes) are used.

In a formal language one might define a negation as putting a minus sign in front of a sign. However, there is little meaning to it. Minus seven (say a commercial loss of €7) added to seven (say a profit of €7) does not give us any dynamical insight, the totality adds up to zero, whose positive negation is ill-defined. In other words, to square axiomatic mathematics with dialectics is trying to apply formal logic in a non-formal logical environment. As an example: Engels writes:

> In a given problem, for example, I have two variables, x and y, [...] I differentiate x and y [...] And now, what have I done but negate x and y [...]? In place of x and y; therefore, I have their negation, dx and dy, in the formulas or equations before me. I continue then to operate with these formulas, treating dx and dy as quantities which are real, though subject to certain exceptional laws, and at a certain point I negate the negation, i.e., I integrate the differential formula, and in place of dx and dy again get the real quantities x and y, and am then not where I was at the beginning, but by using this method I have solved the problem on which ordinary geometry and algebra might perhaps have broken their jaws in vain. (Engels 2010a, 127–128)

Van Heijenoort comments:

> In these two [the first is on Engels' dealing with the sqr of minus one –JK] examples 'to negate' means four different operations: (1) to multiply by -1, (2) to square a negative number, (3) to differentiate, (4) to integrate. What is the common feature of these operations that would allow Engels to subsume them under the concept of negation? A few pages later he tells us that 'in the infinitesimal calculus it is negated otherwise than in the formation of positive powers from negative roots'. But he never gives us the slightest hint as to what distinguishes the four 'negating' operations from other mathematical operations. Or can any mathematical operation be considered as a 'negation'? Then, what does the 'negation of the negation' mean? It is both impossible and useless to criticize Engels' use of this formless notion in the field of mathematics. (Van Heijenoort 1985)

It would go too far in this paper to enter the discussion on Marx's mathematical manuscripts, which Engels so highly praised. It suffices to say that Marx hit the nail on its head in his not unique critique of the calculus of his time. Interesting works have been written about this, but most of them discuss Marx's mathematics in relation to Hegel, which is also Engels' approach. But after the total re-establishment of the calculus at the second

half of the nineteenth century, discussing Marx's critique became an historical exercise and did not lead to a new inroad in mathematics.[11] This does not mean at all that the discussion is over, as in the modern approach no continuum exists, all is discrete (Bell 2019). In other words, some worries of Marx and Engels vis a vis the calculus remain. An interesting aspect is Engels' strong emphasis on the discrete, explicated in his ideas about counting:

> The ten fingers on which men learnt to count, that is, to perform the first arithmetical operation, are anything but a free creation of the mind. Counting requires not only objects that can be counted, but also the ability to exclude all properties of the objects considered except their number—and this ability is the product of a long historical development based on experience. Like the idea of number, so the idea of figure is borrowed exclusively from the external world, and does not arise in the mind out of pure thought. There must have been things which had shape and whose shapes were compared before anyone could arrive at the idea of figure. Pure mathematics deals with the space forms and quantity relations of the real world—that is, with material which is very real indeed. (Engels 2010a, 36–37)

This dovetails with his problems with complex numbers.[12]

It is important to note that Engels is mixing up physical laws and their expression in mathematics. Here, Engels forgets that all laws are human constructs as is evident in his notorious 'mirror image' (*Abbildung, Widerspiegelung*), the idea that human thoughts, and hence mathematics, are more or less one-to-one representations of the material reality outside our skull. Engels writes: "Pure mathematics deals with the space forms and quantity relations of the real world—that is, with material which is very real indeed. The fact that this material appears in an extremely abstract form can only superficially conceal its origin from the external world" (Engels 2010a, 37).

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11. As the Mega² publication of *Marx Mathematical Manuscripts* is still in limbo, there are three publications with appendices and introductions worth to scrutinizing: Sofya A, Yanovskaya and Ersnt (Arnost) Kolman ed: Mathematical manuscripts of Karl Marx, first published in German and Russian, Nauka Press, 1968. For an English Translations (Marx 1983) and (Marx 1994). In French (Marx 1985) and German (Marx 1974).For the history of the calculus see Boyer 1959.
12. The idea of an innate number capability is also a tenet of the works of the cognitive scientists Lakoff and Núñez (Lakoff, and Núñez 2000). Recent anthropological research shows that counting and numbers are not innate but are product of culture, like writing (Everett 2017).

On the other hand, Engels struggles with the fact that abstracted 'laws' phrased in sign (mathematical) language might not be correct and become (platonic) truisms by themselves:

> But, as in every department of thought, at a certain stage of development the laws, which were abstracted from the real world, become divorced from the real world, and are set up against it as something independent, as laws coming from outside, to which the world has to conform. That is how things happened in society and in the state, and in this way, and not otherwise, pure mathematics was subsequently applied to the world, although it is borrowed from this same world and represents only one part of its forms of interconnection—and it is only just because of this that it can be applied at all. (Engels 2010a, 37)

3. NATURE AS EXAMPLE AND INSPIRATION

There is a remarkable aspect in the discussions on materialism and dialectics. Engels "puts on its feet" the idealist construction which Hegel built in order to grasp interpenetrating notions and historical development from simple notions to ever increasing complexity, like the state as an ordering concept in human society. In simple shorthand, Engels is saying that the idea is a human mental and hence material object which results from a material progression from elementary chemical stuff towards what and where we are.[13] The underlying issue is: to what extent can Hegelian categories like quality, quantity, causality, and essence serve as scaffolding for a societal analysis based on a materialistic worldview. As often with scientific theories based on our experiences, we invent an analytical method and by reaching its limits we keep part of the method in a novel context. In the hand of its creator the Hegelian system did not lead to the emancipation of humankind and intrinsically has authoritarian aspects, but essential parts of Hegel's thinking remain.

We need new analytical methods that will help us to understand why the present capitalist system came into being and how it can be transcended. Fully in line with the explosive developments in theoretical and applied sciences and their expression in tempestuous industrialisation, Engels and Marx took up this challenge to research the dynamics in the developments in the economy and its dependence on nature. In so doing, they try to use Hegel's teaching as methodological model, against simple formal logic. Models for the intrinsic metabolism of nature must enable

13. In this respect it is important for further research to scrutinize Evald Ilyenkov's elaborations on the materiality of the Idea (Ilyenkov 2014).

humankind to advance social life in a historically unprecedented way. Prime examples are the investigations in agriculture and hence ground rent. Where is value coming from and how does value be (re)created in a market which in the nineteenth-century mode of production became fully capitalist? Breakthroughs in chemistry exemplified in Liebig's invention of artificial fertilisers changed agriculture for ever. The unavoidable consequences of this innovation for the national and international trade in agricultural products and for the ecological situation of the earth can easily be seen as an example of a "dialectics," a non-linear and non mono-causal next step in human life.[14]

Materialist notions of dialectics became unavoidable, given the tremendously fast developments in fields like geology, cosmology, and heredity (genetics was not yet on the podium) where the historicity of the present became obvious, and the vast expansion in knowledge and models such as electromagnetism and thermodynamics in physics.

There is a real world of which we are part, and we have to take this materialistic starting point to advance our species. In the political struggle it is therefore necessary to strongly oppose lapses back into religion or solipsism. With Engels we see an overjoyed eagerness to show by example that all modern sciences try to understand the world through models of interpenetrating and mutually determining "forces."

Dialectics of Nature seen this way is a collection of examples and attempts to use these examples as building blocks for a more comprehensive argument. It rephrases our human way of thinking within a new "epistemic" framework and results in studies like his famous: *The part played by labour in the transition from ape to man* (Engels 1976, 452). Engels creates a framework that allows historicity—hence change, also in its basic notions—, and a certain level of fluidity in its expressions.

4. ENGELS THE INSPIRER

This bicentennial is a good starting point to hark back to what Engels and Marx wanted to accomplish and to ask ourselves to what extent their inroads into the problem of reaching human emancipation, from misery and oppression, are more than just nineteenth-century first attempts. Their whole *oeuvre* can be seen as a set of attempts to understand the dynamics of social reality as a function of human nature (Geras 1983), and the limits

14. For Marx and Engels inroads into ecology see, e.g., Grundmann 1991; Foster 2000; Altvater 2015; Foster and Burkett 2016; Saito 2017.

and potentialities offered by nature as determinants for life and humanity as an evolutionary species based in planetary evolution (Gould 1988). Human nature, the result of the evolutionary birth of social relations, is firmly grounded in the non- (or not yet) natural pre-human environment. The issue is how our biological substrate (from feet via liver to brain) determines our thinking and a social relation, as well as that our capacity for teleological thinking induces changes to our natural habitat in a 'non-linear' interaction. (for an interesting discussion see Pagel 2012)

To make the notions of motion, change and progress operational, deep inroads have to be made into the study of those fields of human knowledge that enable more or less stable definitions in order to make the step from historical analyses to forecasting. Obviously, astronomy, physics and mathematics then become prime fields of investigation. Engels often expressed enthusiasm for Immanuel Kant's youthful theory (forty years later augmented by Pierre-Simon Laplace) that the planets are products of the condensing, due to gravity, of interstellar dust, which now is known under the name of Kant Laplace Nebular Hypothesis (Kant 2012), and his long discussions on the then new conservation of energy principle, which allows for the dynamic exchange of various physical, chemical, and biological forms of energy (Harman 1982), clearly indicate his striving for a scientific socialism, void of pipe dreams, that accords with the limits as well as intrinsic dynamics of human life as part of nature. As is clear from the correspondences and excerpts of books, Engels and Marx were veracious readers of scientific works.[15]

The nineteenth-century maturation of the sciences served ~~s~~ as an example for the creation of a scientific approach to economy and sociology. Although it remains a highly contested hope to productively import natural science methods, lock, stock and barrel into research in sociology and the humanities. The lack of exact definitions leads to the explosion of statistical methods, including the now popular co-called artificially intelligence. It goes without saying that the humanities face the up-hill battle to develop own methodologies.

Epistemologies come and go with every new discovery (think about Quantum Mechanics). Depending on increasingly better experimental methods and consequently data analyses, we witness a sharpening in the debates, as well as a widening of their scope, e.g., as exemplified by the

15. Evidence of their wide reading is given in the many volumes of Mega2 related to the Marx-Engels correspondence, (Marx and Engels 1999), and (Marx 1982).

impressive new insights in paleozoology and paleontology and the search for human ancestors. Discussions in the natural sciences demand rigour, based on well-defined notions. This induces the same type of demands on fields with less well-defined notions (e.g., the concept of the working class in the social sciences) and hence the unfortunate tendency in the humanities and social sciences to lean too heavily on formal logical, mathematising, and statistical data grinding, which may lead to false expectations of what statistical methods can accomplish. Engels' inroads in natural science certainly signal a hope to transfer "scientific" methods to economy and sociology, but he never achieved this—and neither do we at the moment.

The problem of motion is a fundamental one, as motion (of an object, or a timeline expressed in brain-based or non-human such as fossils memories) always expresses a relation between one object and another, or to e.g., a perceived fixed coordinate system—then seen as an absolute object—in Newtonian physics.

We are still left with some pertinent questions Engels raised: the historicity of knowledge; the materiality of the world; objectivity and realism in epistemology; and the notions of the real, objectivity, reflection, and modelling.

Historicity of Knowledge

The history and sociology of science are quite recent disciplines. They originated in a descriptive literary tradition, of following the presumed linear advancement of ever more encompassing and deeper knowledge. Nowadays, sociologists and historians of science dig deeper into the social context and the historic-economic contingencies of why and how certain advances were made.

Within the historical materialist tradition the famous contribution of Boris Hessen in (Hessen 1931), which was the spark for a strong communist, in particular in the UK, tradition in the field, started with people like Needham, Bernal,[16] etc.

Slowly, this type of simplified, sometimes almost mono-causal, approach (Bernal 1969), gave way to deeper studies in which cultural, philosophical, and religious contexts were becoming part of the understanding. Important works are the early 1935 work of Ludwig Fleck (1979)

16. J.D. Bernal, name giver to so-called Bernalism, remained all his life a missionary for Engels, "[...]there is no doubt that he would be remembered chiefly as one of the foremost scientist- philosophers of the century" (Bernal 1935).

and later Thomas Kuhn (1962), who suggest the existence of clear epistemological communities, as well breaks and shifts in outlook (aka *Paradigms*).

The Materiality of the World

Engels and Marx poke fun at Spiritism (Engels 2010, 352; Marx 1976a), a popular pastime in their time, and combat the idealists. Their materialism was heavily influence by eighteenth-century materialism, according to which materialism was equated with matter: stuff. Engels' enthusiasm for Hermann von Helmholtz, then the most important scientist in Germany, is well expressed in *Anti-Dühring* as well as in *Dialectics of Nature*:

> Modern natural science has had to take over from philosophy the principle of the indestructibility of motion; it cannot any longer exist without this principle. But the motion of matter is not merely crude mechanical motion, mere change of place, it is heat and light, electric and magnetic tension, chemical combination and dissociation, life and, finally, consciousness. (Engels 2010b, 332)

At the turn of the century the notion of electric and magnetic fields matured and "fields" became, along with "stuff," part of the materiality of the world. This introduced theories suggesting the end of matter, such as the energetics concept of Wilhelm Ostwald who, like Ernst Mach, refused to accept the existence of chemical atoms. The next attack on the concept of matter happened with the discovery of radioactive decay, discovered in 1896.

But Engels and certainly Vladimir Lenin put things in a clear perspective. Materialism cannot be tied to the limited human knowledge of a certain period:

> Engels says explicitly that 'with each epoch-making discovery even in the sphere of natural science ['not to speak of the history of mankind'], materialism has to change its form' (Lenin cites: Ludwig Feuerbach, German edition, p. 19). Hence, a revision of the "form" of Engels' materialism, a revision of his natural-philosophical propositions, is not only not "revisionism," in the accepted meaning of the term, but, on the contrary, is an essential requirement of Marxism. (Lenin 1968, 251)

And:

> The great successes achieved by natural science, the approach to elements of matter so homogeneous and simple that their laws of motion can be treated mathematically, caused the mathematicians to overlook matter. 'Matter disappears', only equations remain. At a new stage of development and apparently

> in a new manner, we get the old Kantian idea: reason prescribes laws to nature. (Lenin 1968, 308)

Lenin's battle against the new positivist philosophy that eliminates all unobservables, is phrased as:

> The 'essence' of things, or 'substance', is also relative; it expresses only the degree of profundity of man's knowledge of objects; and while yesterday the profundity of this knowledge did not go beyond the atom, and today does not go beyond the electron and ether, dialectical materialism insists on the temporary, relative, approximate character of all these *milestones* in the knowledge of nature gained by the progressing science of man. The electron is as *inexhaustible* as the atom, nature is infinite, but it infinitely exists. And it is this sole categorical, this sole unconditional recognition of nature's *existence* outside the mind and perception of man that distinguishes dialectical materialism from relativist agnosticism and idealism. (Lenin 1968, 262)

The problem with unobservables is still the key question in quantum mechanics, but this certainly also has to do with the physical limits of the human senses. As Abraham Pais, one of Albert Einstein's biographers' recalls: "I recall that during one walk Einstein suddenly stopped, turned to me and asked whether I really believed that the moon exists only when I look at it. The rest of this walk was devoted to a discussion of what a physicist should mean by the term 'to exist'" (Pais 1979, 907).

Objectivity and Realism in the Discussion on Epistemology

Having stipulated that the world exists prior to humanity (as proven by geology and Darwinism) and presumably also after humanity (depending on the power of the nuclear bomb stock), we reach next the issue of "reflection" as a source for theory construction and modelling. It should be emphasised that materiality is explicitly an important concept in the context of the human body and its disorders.

As Timpanaro (1975b, 67) writes: "If the eighteenth-century theme 'of pleasure and of pain' was too much neglected by Marxism, that was a result of the fact that Marx and Engels had early on identified hedonism with bourgeois individualism in too summary a fashion." Bodily experiences are the only gateways for knowledge and hence science and politics, even if these experiences are elevated to abstract mathematical modelling. But this does not mean that these gateways prove positivistic philosophy. Today, old-fashioned vulgar materialism finds an expression in neurology and brain-research; synapses and neurons are taken as elementary—material—

objects. Moreover, this type of research models brain activity using the basically most primitive, but highly versatile, binary models as expressed in computer science and so-called artificial intelligence. It is based on the success story of the digital computer; their development *pace* claims that in the future quantum computers will create a breakthrough. Interestingly, research on analogue computers fizzled out in the 1970s, with the advance of digital computers, as the latter allowed for ever increasing numerical precision. Again, a cultural shift to the discrete, to the detriment of the analogue continuum.

The Real, Objectivity, Reflection, Modelling

Engels is permanently struggling with the notion of motion or change. After all, history is an expression of change. In his *Dialectics of Nature* essay: 'Basic forms of motion', he explicitly says: "We are compelled to restrict ourselves-in accordance with the state of science-to the forms of motion of non-living nature" (Engels 2010b, 362).

He then continues with the notion of motion in mechanics and the opposite forces of attraction and repulsion, which are related to the energy and momentum conservation laws. The conservation of energy, established by Helmholtz, can be interpreted as an example of a unity of oppositions, together creating motion:

> It is expressly to be noted that attraction and repulsion are not regarded here as so-called *"forces"* but as *simple forms of motion,* just as Kant had already conceived matter as the unity of attraction and repulsion. What is to be understood by "forces" will be shown in due course. (Engels 2010b, 364)

Here we have to understand that with Helmholtz, we have reached the pinnacle of nineteenth-century science based on then obvious truisms such as already formulated by Kant. We have objects, but our knowledge might be incomplete, we traverse a three-dimensional Euclidian space in time and as we advance forward, the notion of causality is unavoidable. Kant's *a priori* assumptions about time and space can easily be understood. How do we approach motion, which is defined in terms of time and place? These notions are still up for review, but nineteenth-century modelling could not do without them.

With the invention of the theory of electro-magnetism as an integrated theory for electricity and magnetism, the limitations of mechanical models were reached, as electro-magnetic fields had then to be understood as based in matter, or in other words expressions of waves in an ether, a carrier such as water for water waves (Harman 1982; Born 1965). The final

blow to nineteenth-century physics struck when new perceptions of space and time were becoming established in special relativity as from 1905 and general relativity (gravitation theory) in 1915; perceiving time and space as dynamic entities.[17] On top of that, quantum mechanics became as from the 1920s the most successful descriptive theory for matter (void of gravity), however without a clue for *Anschauung*. It remains a purely mathematical abstract theory, without popularised pictures such as the rubber sheet as a model for gravitation.[18]

All meaning of human notions changes throughout history. The notion of an atom was seen by the Greeks as the smallest particle of which matter was made. Atoms are now, apart from their metaphorical meaning, only the smallest entity of a chemical element. Nowadays we have experiments demonstrating that such atoms can show interference just like waves, or can cluster in a further unique whole, as in the case of Boson condensation of Rubidium atoms. The endless to and fro between ideas and models looks like walking in a funhouse. But against both the overoptimistic idea of an asymptotical reaching of a final destination (the exit of the funhouse) and Feyerabendian agnosticism (Feyerabend 1989), we have to start with the deep materialist notion that the world is real and so are we as part of nature. The ever increasing amount of knowledge leaves us with the political/moral obligation to apply existing knowledge and advance novel experimental data and their models to fight for a world in which a novel concept of society is established, in which 'everybody works (with pleasure!) according to his/her capacities and receives goods and shelter according to her/his needs'. Saving our species means keeping the globe in situations that allow our species to live. The now imminent ecological crisis proves that our epistemology is a dynamic morphing of phenomena (experimental data) and theories. Both are expressions of human ingenuity.

The necessity to reconsider present-day science in a new way implies that we have to rethink reflections and modelling in the mind (Kircz 2015, 2016).

17. For a more technical book on the history of space see Jammer 1993; for a more wide ranging treatise on space see Schemmel 2016; for a deep more technical work on time see Jammer 2006.

18. This is not the place to review the foggy discussion on quantum mechanics and the almost religious claim that the present hegemonic interpretation is closed and complete, including the idea of Niels Bohr that ultimately we only can think in classical mechanical terms (see Beller 1999).

This whole theme boils down to the eternal quest of to what extent the human brain, as part of the human body, is able to "picture" the objects around and in the human body. This quest has much to do with the unique human capacity of externalising sensorial impressions in formal languages. In other words, do we reflect "reality out there"? Is the mental image a homomorphism (a structure preserving one to one mapping of out-there onto in-here)? As our brain activities such as memory and thinking are constantly in development during our lifetime (until death or dementia strikes), the reflection is clearly in a dynamic laughing mirror. With the advent of positivism by Ernst Mach and William James' pragmatic school, the problem was (dis)solved by positing that in practical life we only have to deal with what can be experienced with our (enhanced) senses. To quote James: "Grant an idea or belief to be true," he says, "what concrete differences will its being true make in any one's actual life? How will the truth be realized? What experiences will be different from those which would obtain if the belief were false? What, in short, is the truth's cash-value in experiential terms?" (James 1987a, 573).

"Truth lives, in fact, for the most part on a credit system. Our thoughts and beliefs 'pass,' so long as nothing challenges them, just as bank-notes pass so long as nobody refuses them. But this all points to direct face-to-face verifications somewhere, without which the fabric of truth collapses like a financial system with no cash-basis whatever" (James 1987a, 576; James 1987b, 821).[19] James' shop keeper metaphor of cash value is a gem for simple historical materialism (Novack 1975).

Engels and subsequently Lenin took the search for a materialistic worldview, or ontology, seriously. This search for the "real" is a sailing between the Scylla of the rocks of pragmatism and the Kantian Charybdis of the never-ending asymptotic whirlpool down to the thing in itself. But like sailing on the high seas, the course is forever morphing between theory and experience.

Lenin himself clearly struggled with this when he wrote the following notorious sentences:

> From Engels' point of view, the only immutability is the reflection by the human mind (when there is a human mind) of an external world existing and developing independently of the mind. No other "immutability," no other "essence," no other "absolute substance," in the sense in which these concepts

19. Obviously James lived in a period that money was related to a gold standard. Presently, even that security is gone.

> were depicted by the empty professorial philosophy, exist for Marx and Engels. The "essence" of things, or "substance," is also relative; it expresses only the degree of profundity of man's knowledge of objects […] (Lenin 1968, 262) (see above for the remainder of this quote on the infinity of nature).

In this passage Lenin argues, on the one hand, against the positivists for "immutability," in line with Engels, and on the other hand states that essence is relative, as nature is infinite. In my view, we can construe this as saying that the physical fact of a blue nail as a result of repairing your home can be seen in a plethora of models, from Nail Bar culture to Subungual Hematoma research. All experiences are theory laden, a notion which was developed later in the twentieth century.

This crucial observation often disappears from view, in particular when we are dealing with modern science (in particular, in quantum mechanics, which is completely formulated in mathematical sign language), in which closed mathematical models disguise clear material experience, e.g., positron-electron collisions giving a flash of light.

The issue of changing models, sometimes phrased as scientific revolutions or paradigm shifts, is a pertinent problem. Neither Engels nor Lenin could grasp it at their time, the period of pinnacle of materialist thinking in Engels' case or challenged materialism in the case of Lenin. The many studies that describe such epistemological changes too often rely on taking the new science as a new truism and frame it in the social context of its birth.

Within the context of this paper, three remarks can be made.

1) There is much new knowledge on non-human perceptions. After Franz Anton Mesmer in the late eighteenth century made inroads with animal magnetism as healing power, which turned out to be hypnoses or group psychology, the idea of animal magnetism in humans became anathema. However, with newer technologies, human biomagnetism (obviously it demanded a new name) has been a fully developed field since the 1970s. It just shows that the traditional five human senses are only a sub-set of what the human body experiences. We simply do not yet have a full overview of how material "impressions" are or can be mentally modelled in new theories about human life as a part of nature (with the help of instruments such as glasses or "SQUIDS" to measure the magneto-encephalogram of the human brain). The elimination of unobservables becomes a lost war. Unfortunately much of the research on other animals than humans is dealing with re-creating animal features for direct human (often military) use, including "living machines"— man-made devices with

capabilities shared by creatures that evolved in nature" (Prescott, Lepora, and Verschure 2018).

This fantastic field is a step in the direction of "enhancing" humanity with novel, not innate, capabilities to survive, by analysing and mimicking non-human perceptions and structures. It not only proves that "nature is infinite," but also makes us wonder about the "worldview" of other animals. The frame rate of the human eye is low, and in motion pictures the rate is now standardised to 24 frames per second and in that way we perceive continues motion. To play safe, the rate of our PC screens is 50 to 60 frames per second. But what about flies? So difficult to catch, and raptors, who see even much faster, till more than 100 frames /second (Potier et al. 2020).

And let us not forget the electric eel, who sees by electric pulses, and whose notion of perspective is very different from ours. In his extreme utilitarian introduction to a popular natural historical book William J. Turkel states:

> The central argument of this book is that our treatment of electric fish as apparatus enabled us to feel our way into electric worlds of our own and, eventually, to inhabit them. More generally, our evolutionary success is due in large part to the fact that we have the ability, perhaps unique, to treat our own bodies and those of other people and other animals as equipment. (Turkel 2013, 3)

This productivist approach, the same as in the afore-mentioned "Living Machines" handbook, does not address the much more interesting question of how these 'strange' animal senses might help us to see nature, beyond our evolutionary-driven diversity. We rounded one corner in evolutionary history, because it fitted best, but that says more about us than about nature.

> [...] this detour in sensory perception in our discourse is that it shows that in nature there exists a manifold of different ways of interpreting the same physical reality, which certainly leads to different social behaviour. Our understanding of the world is an interplay between our analog sensory perceptions and our digital mental cognitive abstractions. The implicate now is, that with the knowledge of different sensory representation schemes, we can simulate them in an electronic publishing environment and can therewith expand the human outlooks on reality which after all is the basis for its desire to change the world. (Kircz 1998)

What if we become able to program the electric eel in an Artificial Reality bodysuit? Will that change our worldview?

2) After leaving the dogma of positivism, and accepting that sense impressions can be hidden from our simplest sensory acuity, the next anti-materialist step was taken by the logical-positivists, in finding the limits of the truth of reality in the search for a perfect (mathematical) language. Although out of fashion now, it is hidden in the surge of mathematical modelling proving so incredible productive in cash terms for e.g., financial capital. The pertinent and oft-posed question why mathematics is so effective is fundamentally ahistorical and undialectical, as argued above. Over the centuries, effective modelling came to the fore as a result of social collective labour.

This brings us to the conclusion, not explicated but suggested by Engels that novel scientific vistas and models will come to the fore in new societal settings. Proof of this suggestion is given in the early days of the USSR when collective labour and culture was the "norm." Let me give two examples. Alexei Kojevnikov shows how the notion of "collective motion" by communist physicists created novel science (Kojevnikov 1999, 2002). This is independent of the bromide that maybe the actors themselves were not staunch communists (Gorelik, 2005). It is about the hegemonic culture.

As these novel ideas about plasmas and quasi-particles, such as phonons (quantized waves in condensed matter), quickly became part of "standard" physics, it is also a proof that material reality is "out there," but that socially-contingent human ingenuity is needed to model the material world as function of its social context. In the same vein Ludmila Hyman, when discussing the difference between the psychologists Piaget and Vygotsky, concludes:

> Piaget worked in a capitalist society in which the individuation of the person was taken for granted, and the individual needed to be socialized. By contrast, Vygotsky worked in a communist society that took the collectivist situation of the person for granted. In Vygotsky's thinking, thus, it was individuation that the person had to develop. (Hyman 2017, 636–637)

3) Epistemology based on the combination and integration of the great variety of different experiences and sense impressions, calls for the notion of an atlas as a kind of encyclopaedic work, which is mostly known from geographical cartography (Kraak and Ormeling 1998), where overlapping two-dimensional projections of patches of the earth allow the human reader to get a sensuous feeling for the real three-dimensional world. At present 3D simulation, also used by e.g., architects, allows the viewer to 'experience' space on a flat 2D screen. At the same time GPS devices, which

instruct drivers where to drive, demolish the remnants of a sense of direction the modern human retained from its hunting and gathering ancestors.

In mathematics and in particular in differential geometry the notion of an atlas is used to allow the understanding of higher-dimensional space. A function (track) in a higher-dimensional space can be analysed in the collection of projections (mappings) onto lower—one (a line) or two (a plane)—dimensional representations. As a matter of fact, humans are used to the two-dimensional plane of the visual retina. Everybody understands that such projections are not the real thing. In a recent major study Daston and Galison (Daston and Galison 2010) dig into the history of the scientific genre of the Atlas, as a large picture book presenting an inventory of e.g. birds, flowers, radiological recordings, etc. In this case the atlas is considered as a genuine representation. The authors propose three types of objectivity that follow each other in historical time, each with their own epistemology. The first phase was the *truth to nature* style in which the scientist works in close collaboration with the artists who draw or paint the object and the printer who multiplies those pictures. The second phase *mechanical reproduction,* exemplified by photography, suggested a more complete objectivity. Epistemologically, however, the discussion is more complicated and both phases developed into what Daston and Galison call *Structural Objectivity*, an expression of the idea that not objects but laws (or models) are representing the real world. A final stage is what the authors call *trained Judgement*, which is exactly what we hope that our medical students are trained in. In medical textbooks, pictorial instructions of e.g., an ulcer or a serious fracture are more of an enhanced *truth to nature* than a photographic representation.

Again we are confronted with the tension between clean modelling in formal theory and the muddy world we are living in.

5. CONCLUSION

In celebrating Friedrich Engels 200th anniversary it does not make sense to list all his mistakes, poor examples and lack of knowledge. Science goes on and we have to hark back to Engels as a formidably inquisitive, widely cultured, social, and enormously productive intellectual. Engels and his lifelong collaborator Marx wanted to know in order to change society.

Earlier we mentioned Karl Marx's second thesis on the German philosopher Ludwig Feuerbach. Thesis eleven reads: "The philosophers have only interpreted the world in various ways; the point is to change it" (Marx

1976b). This slogan is battle cry for socialist action. This aphorism, like all battle cries, demands more flesh on the bones. Marx was right, it is not only about interpretation, that is to say, to try and explain where we are and how we arrived at this temporal place. The issue is: where do we go as human society? The goal of our exercise is to steer the world into a new direction, hence, to change the world, based on the best knowledge of the present and our ever-changing understanding of its dynamics. Continuing this march will be the best way to remember Engels.

The slogan, *a concrete analysis of a concrete situation* is a well-known quip of Lenin. Lenin uses this phrase only once; in a review of the journal *Kommunismus*, in which he criticises the Hungarians Georg Lukács and Bela Kuhn, the full sentence reads:

> Comrade B. K. criticises on the basis of quotations from Marx, which refer to a situation unlike the present one, he wholly rejects the tactics of the German Communist Party's Central Committee and absolutely evades what is most important, that which constitutes the very gist, the living soul, of Marxism—a concrete analysis of a concrete situation. (Lenin, 1974, 166)

Translated to our times (Kircz 2020): Stop quoting Engels, try to advance his example! Take the latest knowledge in all areas seriously and then based on that develop a dynamic emancipatory theory.

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