

II.2. Physical Systems

Dialectical Philosophy and Self-organisation

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Abstract

The aim of this paper is to show that the theory of self-organisation in some respect proves the topicality of dialectical materialism and that an alternative concept of substance makes sense within the framework of dialectical materialism. The first part of the paper shows that Marx and Engels opposed the notion of substance because for them this notion was connected with the assumption of mechanical materialism that there is an eternal, unchanging stuff in the world to which all existence can be reduced. An alternative concept of substance is implicitly present in Engels' works because he says that the eternal aspect of the world is that matter is permanently changing and moving and producing new organisational forms of matter. Ernst Bloch has explicitly formulated this concept of process-substance within the framework of dialectical materialism and in opposition to mechanical materialism. Such an alternative conception of substance can as the second part of this paper shows also be expressed as the permanent and eternal self-organisation of matter. Concepts from self-organisation theory such as control parameters, critical values, bifurcation points, phase transitions, non-linearity, selection, fluctuation and intensification in self-organisation theory correspond to the dialectical principle of transition from quantity to quality. What is called emergence of order, production of information or symmetry breaking in self-organisation theory corresponds to Hegel's notions of sublation (*Aufhebung*) and negation of the negation. Self-organisation theory shows that Engels' *Dialectics of Nature* is still very topical and that dialectical materialism contrary to mechanical materialism and idealism hasn't been invalidated, it rather seems to be confirmed that dialectics is the general principle of nature and society.

1. Matter and Substance in Dialectical Materialism

Friedrich Engels has formulated some theses of a dialectical philosophy of nature that have remained very topical until today:

The real unity of the world consists in its materiality (1878: 41)

The basic forms of all being are space and time, and there is no being out of space and time (1878: 48).

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Motion is the mode of existence of matter. There is no matter without motion and no motion without matter. Both are uncreatable and indestructible (1878: 55)

The human mind is the highest product of organic matter (1886a: 313; 1886b: 341).

Nature does not just exist, but comes into being and passes away (1886a: 317), it has its existence in eternal coming into being and passing away, in ceaseless flux, in un-resting motion and change (ibid.: 320).

Matter is eternally changing and moving, “we have the certainty that matter remains eternally the same in all its transformations, that none of its attributes can ever be lost, and therefore, also, that with the same iron necessity that it will exterminate on the earth its highest creation, the thinking mind, it must somewhere else and at another time again produce it“ (1886a: 327).

Nature forms a system, an interconnected totality of bodies which react on one another, this mutual reaction constitutes motion (1886a: 355)

The basic form of all motion is approximation and separation, contraction and expansion – *attraction* and *repulsion* which are dialectical poles of movement (1886a: 356f).

Matter is the totality of matters from which this concepts abstracts. Words like matter and motion are abbreviations¹, which combine many different, sensually perceivable things according to their common properties (1886a: 503). Matter is an abstraction in the sense that we abstract from the qualitative differences of things and combine them as physically existing in the concept of matter (ibid.: 519).

Matter is the totality of objects that constitute reality and is itself constituted in space and time by an interconnected totality of bodies which react on one another (motion), i.e. they repulse and attract each other. Motion is the mode of existence of matter in space-time. Matter is an eternal process of becoming and passing away, a ceaseless flux, it is uncreatable and indestructible. Matter is the totality of

¹ Also for Hegel, matter is an abstraction. He defines the Thing as the determined and concrete unity of Ground and Existence. It consists of matters or materials which are themselves partly things, which in that way may be once more reduced to more abstract matters. Numerous diverse matters coalesce into the one Matter. “Thus Matter is the mere abstract or indeterminate reflection-into-something-else, or reflection-into-self at the same time as determinate; it is consequently Thinghood which then and there is the subsistence of the thing. By this means the thing has on the part of the matters its reflection-into-self [...]; it subsists not on its own part, but consists of the matters, and is only a superficial association between them, an external combination of them“ (Hegel 1874: §127).

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objective, really existing systems that are interconnected and accord to different physical laws. Matter exists independently from human consciousness, the latter is a specific organisational type of matter. The material unity of the world means that the motion of matter results in a natural hierarchy of relatively autonomous forms of movement of matter where each level has new, emergent qualities that can't be reduced to lower levels or an assumed "materia prima". Time is an expression of the irreversible changing state of matter. Movement in time means movement in space and vice versa. Both space and time express the permanence of change that is a fundamental property of matter. Matter permanently organises itself and produces an irreversible sequence of states.

Attraction and repulsion are the essence of matter (Hegel 1874: §§97f)², as polar opposites they are "determined by the mutual action of the two opposite poles on one another, [...] the separation and opposition of these poles exists only within their unity and inter-connection, and, conversely, [...] their inter-connection exists only in their separation and their unity only in their opposition" (Engels 1886a: 357).

Energy is mass in movement. Energy is also the measure of the capacity of a physical system to undergo change (Marquit 1980). The unity of attraction and repulsion forms a field that surrounds and influences particles. Matter and energy are two forms of one and the same thing, mass is condensed energy and energy radiated mass. Energy is not something external to matter, it is inherent to matter. Einstein has shown that energy and mass are equivalent, hence energy has mass and mass energy. This seems to prove the assumption of dialectical materialism that mass and energy are the same – Engels described energy as the mode of existence, the inherent attribute, of matter. Energy is produced and transmitted

² "The One, as already remarked, just is self-exclusion and explicit putting itself as the Many. Each of the Many however is itself a One, and in virtue of its so behaving, this all rounded repulsion is by one stroke converted into its opposite – Attraction [...]. But the Many are one the same as another: each is One, or even one of the Many; they are consequently one and the same. Or when we study all that Repulsion involves, we see that as a negative attitude of many Ones to one another, it is just as essentially a connective reference of them to each other; and as those to which the One is related in its act of repulsion are ones, it is in them thrown into relation with itself. The repulsion therefore has an equal right to be called Attraction; and the exclusive One, or Being-for-self, suppresses itself. The qualitative character, which in the One or unit has reached the extreme point of its characterisation, has thus passed over into determinateness (quality) suppressed, i.e. into Being as Quantity" (Hegel 1874: §97f).

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from one atom to another only in portions of a certain extent (quanta, Max Planck). The atom emits (or gains) energy as it moves from one stationary state to another. Energy is not emitted or absorbed in a continuous manner, but rather in small packets of energy called quanta. An atom moves from one energy state to another state in steps. The energy of a quantum depends on the frequency of radiation and Planck's constant ($E = f \times h$), or expressed another way the frequency of radiation can be described as $f = (M \times c^2)/h$. This also means that particles are fields and that a particle with a mass M is connected with a field of frequency $(M \times c^2)/h$. The complementarity relation (Niels Bohr) says that for each type of particle there is a corresponding wave-field. "The laws of quantum mechanics fly in the face of 'common sense' (i.e., formal logic), but are in perfect consonance with dialectical materialism" (Woods/Grant 2002: 103).

Bohr and Rutherford have shown that atoms are not the smallest parts of the world. In it we find electrons circling around the nucleus that consists of protons and neutrons that are themselves no elementary particles, but consist of quarks. Elementary particles (6 types of quarks, 6 types of leptones) are not an immoveable substance, they are transforming themselves. The stuff our world is made of are atoms, pure materials or elements. We know 118 pure materials (periodic table). They combine and form molecules that have new qualities. Radioactivity and quantum theory don't mean the "disappearance of matter". Particles and energy are both structural forms of matter. Elementary particles seem to disappear and reappear, they can't be considered as changeless substance, but as Erwin Schrödinger said they are "more or less temporary entities within the wave field whose form and general behaviour are nevertheless so clearly and sharply determined by the laws of waves that many processes take place as if these temporary entities were substantial permanent beings" (Schrödinger 1953: 16).

These physical conceptions such as Heisenberg's conception of the field as the source of particles, the assumption of quarks as elementary particles etc. show that the source of existing forms of matter is itself material and that the unity of the world is its materiality (Hörz 1976)³. Mechanical materialism has been invalidated by modern physics, but not so dialectical materialism. The latter's assumption that the world is in constant flux and process-like has been asserted. Engels basic

³ "The process of continual change which characterizes the world at the subatomic level is a striking confirmation of the fact that dialectics is not just a subjective invention of the mind, but actually corresponds to objective processes taking place in nature. This process has gone on uninterruptedly for all eternity. It is a correct demonstration of the indestructibility of matter – precisely the opposite of what it was meant to prove" (Woods/Grant 2002: 105).

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hypotheses about the dialectics of matter still remain topical. Complementarity doesn't mean a dualistic, but a dialectical relationship of wave and particle.

Certain subjectivist interpretations of the uncertainty principle (impossibility of exactly measuring position and momentum of an electron at the same time), the theory of relativity and the Copenhagen interpretation of quantum mechanics hold that the world only exists and is real when we observe it. The thought experiment by Erwin Schrödinger known as "Schrödinger's cat" shows the absurdity of such idealist assumptions and illustrates that the world exists independently of our observation (although it surely can be observed in different ways and on different levels; and observation can change reality⁴).

In quantum mechanics the psi-function is a means for predicting the probability of measurement results, it is determined by a finite number of suitably chosen measurements on the object, half as many as were required in the classical theory. Schrödinger introduces the example of the cat in order to show that a purely subjectivist interpretation of quantum mechanics results in ridiculous and paradoxical cases. "A cat is penned up in a steel chamber, along with the following device (which must be secured against direct interference by the cat): in a Geiger counter there is a tiny bit of radioactive substance, *so* small, that *perhaps* in the course of the hour one of the atoms decays, but also, with equal probability, perhaps none; if it happens, the counter tube discharges and through a relay releases a hammer which shatters a small flask of hydrocyanic acid. If one has left this entire system to itself for an hour, one would say that the cat still lives *if* meanwhile no atom has decayed. The psi-function of the entire system would express this by having in it the living and dead cat (pardon the expression) mixed or smeared out in equal parts" (Schrödinger 1980).

Energy and information don't exist outside of or external to matter, they are specific aspects of the movement and development of matter and as such are integral aspects of the world.

In Ionian philosophy there was the idea of prime matter. For Thales the prime matter (Urstoff) was water, for Anaximander "apeiron", for Anaximenes air, for Heraklit fire. The Atomists Demokrit and Leukipp reduced all being to smallest

⁴ The appearance of phenomena such as distance, speed, luminance, time, space, etc. depends on the position of the observer, but this doesn't mean that the essence of material reality is determined by observation. There is in fact a difference between essence and appearance. Material reality is infinite and constantly changes, it also exists outside of human observation. If human observers are absent, there still is the motion of matter in space-time.

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parts of the world that are not dividable, move spontaneously and join or repel when colliding. From them there are eternal and indestructible corpuscles. The cosmos is seen as a system that is structured by the collision of atoms, the atoms themselves are considered as substance that doesn't change. These early positions can be considered as materialist monism.

Aristotle who tried to combine Ionian materialism and Elatic idealism postulated that substance always remains the same, nothing becomes or passes away, the same nature always maintains itself. For Aristotle there is substance (essence) and accident (contingency), hyle (substance) and eidos (form). Form and substance are two aspects of a thing that can't be divided, the only form without substance would be God. His position is one of ontological dualism, besides material being there is immaterial being.

The Middle ages were dominated by a religious conception that considered matter as a creation of God. This was questioned by Pantheistic conceptions such as the one of Giordanno Bruno that considered God as an eternal force that is immanent in nature. The Newtonian world-view was characterised by its believe in absolute immutability of nature and a reductionistic methodology. Nature was considered as a conservative system that remains stabile from its beginning until its end, organic matter was reduced to mechanics. French materialism of the 18th century (LaMettrie, Holbach, Diderot, Helvétius, Condillac, Alembert, Condorcet, Bonnet, Robinet, Laplace) as well as the "mechanical materialists" (Engels 1886b: 342) of the 19th century (Moleschott, Büchner, Vogt) were influenced by this worldview. The human being was considered a machine and the universe wasn't comprehended "as a process, as matter undergoing uninterrupted historical development" (Engels 1886b: 342). Relatively autonomous objective systems with higher forms of motion were reduced to mechanical ones.

Marx, Engels as well as Hegel (the latter remained trapped in irrational thinking, although he revolutionised philosophical methodology) were highly critical of the Newtonian worldview. They emphasised interconnection and processes instead of singularities and reduction. Hegel criticised atomistic philosophies (Hegel 1874: §§ 97, 98) by saying that they fix the One as One, the Absolute is formulated as Being-for-self, as One, and many ones. "It doesn't see that the One and the Many are dialectically connected: the One is being-for-itself and related to itself, but this relationship only exist in relationship to others (being-for-another) and hence it is one of the Many and repulses itself. But the Many are one the same as another: each is One, or even one of the Many; they are consequently one and the same. As those to which the One is related in its act of repulsion are ones, it is in them thrown into relation with itself and hence repulsion also means attraction".

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Marx criticised the reductionism of individualism in his critique of Max Stirner (Marx/Engels 1846: 101-438) and put against this the notion of the individual as a social being that is estranged in capitalism and can only become a well-rounded individual in communism (see Fuchs/Schlemm 2002). Engels criticised the reductionism and individualism of “metaphysical thinkers”: “To the metaphysician, things and their mental reflexes, ideas, are isolated, are to be considered one after the other and apart from each other, are objects of investigation fixed, rigid, given once for all. He thinks in absolutely irreconcilable antitheses. "His communication is 'yea, yea; nay, nay'; for whatsoever is more than these cometh of evil". For him a thing either exists or does not exist; a thing cannot at the same time be itself and something else. Positive and negative absolutely exclude one another, cause and effect stand in a rigid antithesis one to the other“ (Engels 1878: 20f). “Hard and fast lines are incompatible with the theory of evolution. [...] For a stage in the outlook on nature where all differences become merged in intermediate steps, and all opposites pass into one another through intermediate links, the old metaphysical method of thought no longer suffices. Dialectics, which likewise knows no hard and fast lines, no unconditional, universally valid 'either...or' which bridges the fixed metaphysical differences, and besides 'either...or' recognises also in the right place 'both this – and that' and reconciles the opposites, is the sole method of thought appropriate in the highest degree to this stage“ (Engels 1886a: 482).

Self-organisation theory today also stresses the interconnectedness and process-structure of the world and criticises reductionism. Also Ilya Prigogine and Isabelle Stengers, the founders of dissipative systems theory, stress that Hegel and Marxism are important process-thinkers: “The Hegelian philosophy of nature systematically incorporates all that is denied by Newtonian science. In particular, it rests on the qualitative difference between the simple behavior described by mechanics and the behavior of more complex entities such as living beings. It denies the possibility of reducing those levels, rejecting the idea that differences are merely apparent and that nature is basically homogenous and simple” (Prigogine/Stengers 1984: 89). “The idea of a history of nature as an integral part of materialism was asserted by Marx and, in greater detail, by Engels. Contemporary developments in physics, the discovery of the constructive role played by irreversibility, have thus raised within the natural sciences a question that has long been asked by materialists. For them, understanding nature meant understanding it as being capable of producing man and his societies” (Prigogine/Stengers 1984: 252).

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Marx and Engels opposed the idea of substance (an endless, changeless carrier of changing qualities⁵) as *materia prima* because they considered such positions as mechanical and undialectical, neglecting that matter is always in motion and in its dialectical process of becoming develops higher organisational levels. Hence if one takes a look at the history of dialectical materialism one will find an animosity towards the notion of substance. E.g. Lenin wrote: “The recognition of immutable elements, “of the immutable substance of things,” and so forth, is not materialism, but *metaphysical, i.e., anti-dialectical, materialism*“ (Lenin 1952: 251). Herbert Hörz (1976: 222ff), one of the main philosophers of the GDR, argued that due to field physics, the discovery of radioactivity, relativity theory and quantum theory, the notion of substance has become untenable. Modern physics has shown that elementary particles are transformed into other ones, the existence and maintenance of a particle is only possible in relationship to other particles and the latter’s qualities. Hence the idea of an unchangeable carrier of qualities seems no longer to be valid. “Whereas the notion of substance presupposes a changeless carrier, [...] modern physics conceives material events primarily as change, interaction and searches for the structural laws of this change” (Hörz 1976: 225). The notion of substance wouldn’t be able to show the dialectical relationship of particle and field that was introduced by quantum theory. Field and elementary particles wouldn’t be substance because they aren’t changeless.

Hegel opposed the notion of substance for other reasons: Spinoza sees substance as *causa sui*, it is its own reason, Hegel says that such an assumption would exclude the creation of the world by God that he believed in. “A deeper insight into nature reveals God as creating the world out of nothing. And that teaches two things. On the one hand it enunciates that matter, as such, has no independent subsistence, and on the other that the form does not supervene upon matter from without, but as a totality involves the principle of matter in itself“ (Hegel 1874: §128, see also §§150f).

Due to modern physics a mechanistic and reductionistic conception of substance must be repudiated. Nonetheless there seems to be an alternative conception of substance immanent in Engels’ works on nature themselves: The substance of the world, i.e. that which exists permanently and endlessly, is the process-structure of matter. Matter is unresting, in permanent motion, in ceaseless flux and a self-producing entity. In its dialectical movement it produces different organisational levels that have higher, emergent qualities which can’t be reduced to older

⁵ Also Kant assumed a permanence of substance and said that “throughout all changes in the world *substance* remains, and that only the *accidents* change“ (Kant 1787: 214)

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qualities. Rainer Zimmermann (1999) shows that such a materialistic conception of substance can be traced back to the line of thought constituted by Benedictus de Spinoza – Friedrich Wilhelm Schelling – Ernst Bloch. And it seems apparent that also Karl Marx and Frederick Engels seem to fit into this line as is e.g. shown by Engels' assumption that matter is a producing entity and through its permanent flux and motion "remains eternally the same in all its transformations".

Other than in the reductionistic worldview that saw nature as enemy and tried to reduce all forms of being to a stabile and unmoving matter, Giordano Bruno, Spinoza and Schelling considered nature as a producing and process-like entity. Ernst Bloch sees this line as a historical alternative to the "block"-matter and the "root-thinking" of mechanistic materialism (Bloch 2000: 166ff). In opposition to the standard-assumption of their times that matter was created by God, these philosophers insisted that nature has its own reason and is producing itself.

The Marxist philosopher Ernst Bloch worked out an alternative conception of substance and matter within the framework of dialectical materialism (for details see Zeilinger 2002). In opposition to mechanical materialism⁶ Bloch argues that matter is process-like, it is not a "dead block, moved only by pressure and push and remaining itself all the time" (Bloch 1963: 230), but nonetheless he doesn't give up the notion of substance. Matter for Bloch is fermenting and process-like (Bloch 1963: 203), it is a process-being, being-in-possibility (*dynamei on*; 1963: 207) and has a historical-dialectical character (1963: 209). Matter as clade would be the fermenting sapling (*gärender Schoss*) of a substance that is bearing, developing, clarifying, qualifying itself (Bloch 2000: 173). Motion in its full extent would be the form of existence of matter: motion, change, production, tendency and latency (2000: 176).

Not-Yet characterises the tendency of material processes, as the origin that is processually emerging and tending towards the manifestation of its content (1963: 219). The *Novum* (see Bloch 1963: 227ff; 1975: 141ff) is grounded in the real possibility of a Not-Yet-Having-Become, it is the land of perspectives of the process itself, something that has never been and is real future. As such, it is never completely new. The *novum* opens up the possibility of "active hope", but it is not necessarily "a good one", it can cause "fear as well as hope", it includes the "double-possibility of crash and rise". It is a "moment of could-become-other" (*Anderswerdenkönnen*) in objective-real possibilities, one could say one of relative

⁶ Bloch says that mechanical materialism has a concept of matter that is only analytical and static, it doesn't know history, perspective and horizons of transformation (Bloch 1963: 208).

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chance. Matter both contains tendency and latency (Bloch 1975: 144ff). Tendency means relative determination and necessity in the development-process of the world, latency is a force which drives the process towards a goal and forms spontaneously new structures. Latency drives towards a novum. Tendency in contrast to laws is undecided, for its decision it is in need of a “subjective factor”, it has room for chance and the novum. Latency means an open, broad plurality. In latency, tendency has its pre-existence of its direction and its anticipation.

Bloch’s concept of matter anticipated the modern theories of self-organisation which also stress the productivity of matter that results in different organisational forms and hierarchical levels of matter and the self-reproduction and re-creativity of self-organising units. Nature is for Bloch a producing subject, he says it is forming itself, forming out of itself (1963: 234). In this context Bloch takes up Spinoza’s concept of *natura naturans* in order to stress that nature is not only passively produced, it is also itself an actively producing system. The relationship of tendency and latency in matter also reappears as a dialectic of chance and necessity in self-organisation theory (the concepts of relative chance by Kolmogorow and Chaitin and of incomplete determinism). What Bloch calls a novum is called emergent qualities in the sciences of complexity. Bloch used the term “emergence” himself by stressing that all gestalt figures *emerge* from the dialectical process and from matter as developing, producing (*ausgebären*⁷) substance immanently as well as speculatively (Bloch 1975: 165). For Bloch matter is a dialectically developing, producing substance.

Substance for Bloch is *process-substance* (1975: 246), it opens up possibilities, is fermenting and actively producing. It is “germ and utopian totum of the *materia ultima* in the laboratory of the world” (ibid.). Such a concept of substance seems to be an alternative to the “passive block-“ and “root-“substance of mechanical materialism. Bloch explicates such an understanding, whereas it was implicitly present in Engels’ works who didn’t speak of substance, but about the eternal self-transformation and dialectical movement of matter.

Bloch stresses the important role of the human being in the self-transformation of matter. An organisational form of matter that would guarantee freedom and happiness would ultimately depend on human activities. Also Marx was interested in the relationship of man and nature and like Bloch considered the man-nature-totality as a self-organising system. In his *Economic-Philosophical Manuscripts* he stresses that in the production of his life which includes the metabolism between

⁷ the German term used by Bloch is “ausgebären“ which corresponds on the one hand to “bearing“, but not only points at an active production, it also refers to a developing process

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society and nature and social reciprocity, man as the universal, objective species-being produces an objective world (gegenständliche Welt) and reproduces nature and his species according to his purposes. He says that “nature is man’s inorganic body – that is to say, nature insofar as it is not the human body. Man lives from nature – i.e., nature is his body – and he must maintain a continuing dialogue with it is he is not to die. To say that man’s physical and mental life is linked to nature simply means that nature is linked to itself, for man is a part of nature“ (Marx 1844a: 515f). Marx says that animals only produce their immediate needs, whereas man as the universal, objective species-being through production and the dialogue with nature not only produces himself, he also “reproduces the whole of nature“ (ibid.: 516). So also for Marx human activity is decisive for the self-reproduction and self-transformation of the man-nature-system. Exploitation and estrangement in capitalism would result in a destruction of this system and hence Marx argues (just like Bloch did 100 years later) that the sublation of this social formation is a necessary condition for the true appropriation of man’s nature. “This communism, as fully developed naturalism, equals humanism, and as fully developed humanism equals naturalism“ (Marx 1844a: 536). Bloch adds that a “good novum“ would mean “materialisation of the human being, humanisation of matter“ (Bloch 2000: 176).

2. Self-organisation and Dialectics

Saying the substance of the world is the permanent dialectical movement of matter and its self-productivity, corresponds to saying that matter organises itself and nature is a self-organising system. Wolfgang Hofkirchner (1993) has stressed that the new results of scientific research have been anticipated by Marx and Engels and that the concept of dialectical development re-enters science with self-organisation theory (see also Hofkirchner 1998)⁸.

⁸ „Prima facie mag es ketzerisch anmuten, just in dem Augenblick, in dem mit der Abdankung der bisher einzig real versuchten Sozialismen marxistisches Denken von der Realität überholt worden zu sein scheint, annehmen zu wollen, dass die Ergebnisse der naturwissenschaftlichen Forschungen seit den Tagen von Marx und Engels im Detail eigentlich nur nachgeholt hätten, was diese mit ihrer Natur und Gesellschaft umgreifenden Entwicklungskonzeption philosophisch vorweggedacht hatten. Tatsächlich aber ist es gerade der Entwicklungsgedanke, der mit den neueren Theorien in alle naturwissenschaftlichen Disziplinen spontan hereinbricht, während er sich auf dem Gebiet der Gesellschaftswissenschaften diskreditiert hat, als er zur stalinistisch-kommunistischen Eschatologie einer vorgeblich linearen und unvermeidlichen Abfolge fünferlei Gesellschaftsordnungen verkommen war – zu

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The theory of self-organisation has led to a change of scientific paradigms: from the Newtonian paradigm to the approaches of complexity. There is a shift from predictability to non-predictability, from order and stability to instability, chaos and dynamics; from certainty and determination to risk, ambiguity and uncertainty; from the control and steering to the self-organisation of systems, from linearity to complexity and multidimensional causality; from reductionism to emergentism, from being to becoming and from fragmentation to interdisciplinarity. This has been interpreted as a shift from modern to post-modern knowledge (Best/Kellner 1997).

Concepts of physical self-organisation have been put forward by Ilya Prigogine's theory of dissipative systems (Nicolis/Prigogine 1989, Prigogine 1980), Hermann Haken's (1978, 1983) synergetics and Manfred Eigen's hypercycle-theory (Eigen/Schuster 1979).

Principles of physical self-organisation are (see Fuchs 2001, Ebeling/Feistel 1994):

1. *control parameters*: a set of parameters influences the state and behaviour of the system
2. *critical values*: if certain critical values of the control parameters are reached, structural change takes place, the system enters a phase of instability/criticality
3. *fluctuation and intensification*: small disturbances from inside the system intensify themselves and initiate the formation of order
4. *feedback loops, circular causality*: there are feedback loops within a self-organising system; circular causality involves a number of processes p_1, p_2, \dots, p_n ($n \geq 1$) and p_1 results in p_2 , p_2 in p_3 , \dots , p_{n-1} in p_n and p_n in p_1 .
5. *non-linearity*: in a critical phase of a self-organising systems, causes and effects can't be mapped linearly: similar causes can have different effects and different causes similar effects; small changes of causes can have large effects whereas large changes can also only result in small effects (but nonetheless it can also be the case that small causes have small effects and large causes large effects).
6. *bifurcation points*: once a fluctuation intensifies itself, the system enters a critical phase where its development is relatively open, certain possible paths of development emerge and the system has to make a choice. This means a dialectic of necessity and chance. Bifurcation means a phase transition from stability to instability.
7. *selection*: in a critical phase which can also be called point of bifurcation, a selection is made between one of several alternative paths of development

einem Schematismus, der mit der ursprünglichen Marxschen Theorie der gesellschaftlichen Entwicklung nichts zu tun hatte“ (Hofkirchner 1993: 7f).

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8. *emergence of order*: in a critical phase, new qualities of a self-organising system emerge; this principle is also called order from chaos or order through fluctuation. A self-organising system is more than the sum of its parts. The qualities that result from temporal and spatial differentiation of a system are not reduceable to the properties of the components of the systems, interactions between the components result in new properties of the system that can't be fully predicted and can't be found in the qualities of the components. Microscopic interactions result in new qualities on the macroscopic level of the system. Checkland (1981: 314) defines an emergent quality in similar terms "as a whole entity which derives from its component activities and their structure, but cannot be reduced to them".
9. *information production*: new qualities of a self-organising system emerge and have certain effects, i.e. a complex reflective relationships is established between the trigger of self-organisation (the reflected), the emergent qualities (the result of reflection) and the function the new qualities fulfil for the system in its adaptation to its environment. We have defined this relationship as information, self-organising systems are information-producing systems, information is not a pre-existing, stable property of a complex system
10. *fault tolerance*: outside a critical phase, the structure of the system is relatively stable concerning local disturbances and a change of boundary conditions
11. *openness*: self-organisation can only take place if the system imports entropy which is transformed, as a result energy is exported or as Prigogine says dissipated
12. *symmetry breaking*: the emerging structures have less symmetry than the foundational laws of the system
13. *inner conditionality*: self-organising systems are influenced by their inner conditions and the boundary conditions from their environment
14. *relative chance*: there is a dialectic of chance and necessity in self-organising systems; certain aspects are determined, whereas others are relatively open and according to chance
15. *complexity*: the complexity of a system depends on the number of its elements and connections between the elements (the system's structure). There are three levels of complexity: 1. there is self-organisation and emergence in complex systems, 2. complex systems are not organised centrally, but in a distributed manner; there are many connections between the system's parts, 3. it is difficult to model complex systems and to predict their behaviour even if one knows to a large extent the parts of such systems and the connections between the parts

One example of physical self-organisation are the Bénard-cells: A special liquid is heated at a certain temperature t_2 from beneath and cooled down at a certain

temperature t_1 from above. So there is a temperature-difference $\Delta t = t_2 - t_1$ which develops and is the control parameter of the system (principle 1). At $\Delta t = 0$ the system is in equilibrium, the temperature gradient rises and at a certain critical value (p2), a new pattern emerges in the liquid that looks like honeycombs (p8, p9). The liquid particles are located in layers, lower layers are due to the temperature warmer than upper ones, they expand and their density decreases. At the beginning of the critical phase, a first small fluctuation is caused which means that a particle is thrown out of its position in a certain layer and enters an upper or lower layer (p3). It is not predetermined in which layer this fluctuation will occur. Fluctuations only take place if a certain threshold of the control parameter Δt is crossed. The fluctuation intensifies itself (p3), more and more liquid particles are detached from their stationary position, disorder, chaos and motion shows up (p6). The liquid particles arrange in cells that have different forms (round, square, broad, thin, large, small etc.). These forms are dependent on modes, which are elementary forms of motion. At a certain point of time, several types of cells exist. Finally one type can assert itself, there is one dominant form due to a selection process within the system (p7). As a result of the superimposition of many of the same form, a pattern emerges that looks like a honeycomb (p8, p9). So from an initial chaos of particles, order has emerged. At a certain value of the temperature gradient, this order disappears. In this process, it is determined that order will emerge, that there will be initial fluctuations which spread out and that one of several types of roles will be selected. But it is not determined in which layer the fluctuation will be caused, how the cell-types will exactly look like and which one will be selected (p14). This experiment will only be successful if energy in the form of a temperature difference will be applied to the system (p11).

Another example that is frequently used in order to explain self-organisation, is the functioning of a laser (see Haken 1987). A laser consists of an active medium that is situated between two mirrors. This medium is either a gas that is radiating due to the discharge caused by current entry or a crystal that is pumped through a flash lamp (e.g. a ruby with chrome ions can be used). The atoms of the crystal are stimulated by the flashes and an electron changes its trajectory, it jumps from an inner trajectory to an outer one and takes up energy from the flash lamp. It spontaneously returns to its former trajectory and emits energy in the form of a light wave. So due to the stimulation of the atoms caused by the flash lamp, the atoms emit light waves. The two mirrors again and again reflect the light. First there is a chaos of light waves. A light wave can hit other atoms and force them to intensify its own light. By such processes, the light waves reach certain amplitudes. Hermann Haken says that one light wave "enslaves" the others, this means that it becomes dominant and orders the system. As a result an ordered light wave, the laser beam, emerges. From a chaos of light waves an ordered pattern emerges (p8,

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p9). The decisive control parameter is current supply (p1, p11), the system can only enter criticality if the current reaches a certain threshold (p2). A light wave is caused by a fluctuation, i.e. an electron returns to its inner trajectory and emits energy; a light wave can intensify itself by “enslaving” electrons (p3). Such an intensification always means circular causality, because an entity causes the behaviour of another entity and this behaviour results in a transformation of the first entity (p4). Due to such intensifications, the system enters a state of chaos/instability/bifurcation (p5, p6). A certain light wave is selected (p7) and determines the emergence of the laser beam (p8, p9). It is determined that a laser beam will emerge, that fluctuations and intensification will be caused; but it is not determined how this exactly takes place and which light wave will order the system (p14).

Georg Wilhelm Friedrich Hegel has outlined that the purpose of dialectics is “to study things in their own being and movement and thus to demonstrate the finitude of the partial categories of understanding” (Hegel 1874: Note to §81). Self-organisation refers to the forms of movement of matter and hence is connected to dialectics. What is called control parameters, critical values, bifurcation points, phase transitions, non-linearity, selection, fluctuation and intensification in self-organisation theory (principles 1, 2, 3, 5, 6, 7) corresponds to the dialectical principle of transition from quantity to quality. This is what Hegel has discussed as the Measure (Hegel 1874: §§107ff): The measure is the qualitative quantum, the quantum is the existence of quantity. “The identity between quantity and quality, which is found in Measure, is at first only implicit, and not yet explicitly realised. In other words, these two categories, which unite in Measure, each claim an independent authority. On the one hand, the quantitative features of existence may be altered, without affecting its quality. On the other hand, this increase and diminution, immaterial though it be, has its limit, by exceeding which the quality suffers change. [...] But if the quantity present in measure exceeds a certain limit, the quality corresponding to it is also put in abeyance. This however is not a negation of quality altogether, but only of this definite quality, the place of which is at once occupied by another. This process of measure, which appears alternately as a mere change in quantity, and then as a sudden revulsion of quantity into quality, may be envisaged under the figure of a nodal (knotted) line“ (ibid.: §§108f).

What is called emergence of order, production of information or symmetry breaking in self-organisation theory (principles 8, 9, 12) corresponds to Hegel’s notions of sublation (*Aufhebung*) and negation of the negation. Something is only what it is in its relationship to another, but by the negation of the negation this something incorporates the other into itself. The dialectical movement involves

two moments that negate each other, a somewhat and an another. As a result of the negation of the negation, “something becomes an other; this other is itself somewhat; therefore it likewise becomes an other, and so on ad infinitum” (Hegel 1874: §93). Being-for-self or the negation of the negation means that somewhat becomes an other, but this again is a new somewhat that is opposed to an other and as a synthesis results again in an other and therefore it follows that something in its passage into other only joins with itself, it is *self-related* (§95). In becoming there are two moments (Hegel 1812: §176-179): coming-to-be and ceasing-to-be: by sublation, i.e. negation of the negation, being passes over into nothing, it ceases to be, but something new shows up, is coming to be. What is sublated (*aufgehoben*) is on the one hand ceases to be and is put to an end, but on the other hand it is preserved and maintained (*ibid.*: §185). In dialectics, a totality transform itself, it is self-related. This corresponds to the notions of self-production and circular causality. The negation of the negation has positive results, i.e. in a self-organising system the negation of elements results in positive new qualities.

The two examples mentioned above in fact are examples of the dialectical development of matter. When the control parameters reach a certain threshold, a point of bifurcation or criticality, Hegel says a nodal-line, shows up. The quantities that are increased and transform into quality are the temperature gradient and electric current. The emergence of a pattern of honeycombs and of the laser beam means sublation and negation of the negation. The old state of the systems is eliminated, but nonetheless preserved in new qualities. New qualities show up and hence the systems reach a higher level.

The principle of relative chance that is typical for self-organising systems had already been considered as dialectic of chance and necessity by Hegel, Marx and Engels (Hegel 1874: §§144ff, Engels 1886a: 486-491). Engels has stressed that the dialectic of attraction and repulsion is an aspect of matter and its movement. Both elements are also described by self-organisation theory: Chaos, noise or instability are described as disordered movement of the elements of a complex system. One can also say that the elements are repulsing each other. But this repulsion is one that turns into attraction, because the elements interact, there are processes of ordering and selection, i.e. attraction takes place as the emergence of a coherent whole and new qualities.

As an example for the transition from quantity to quality Engels mentions the homologous series of carbon compounds:

“Here therefore we have a whole series of qualitatively different bodies, formed by the simple quantitative addition of elements, and in fact always in the same proportion. This is most clearly evident in cases where the quantity of all the

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elements of the compound changes in the same proportion. Thus, in the normal paraffins C_nH_{2n+2} , the lowest is methane, CH_4 , a gas; the highest known, hexadecane, $C_{16}H_{34}$, is a solid body forming colourless crystals which melts at 21° and boils only at 278° . Each new member of both series comes into existence through the addition of CH_2 , one atom of carbon and two atoms of hydrogen, to the molecular formula of the preceding member, and this quantitative change in the molecular formula produces each time a qualitatively different body“ (Engels 1878: 119).

Nodal lines or the transition from quantity to quality is today also studied in self-organisation theory. Especially the theory of self-organised criticality (SOC) (Bak 1996) focuses on this. It studies phenomena where perturbations that normally have small effects have large effects in a critical situation and push the system into chaos. A frequently mentioned example is a pile of sand. Dropping grains of sand onto each other will result in a pyramid. When the pile reaches a certain critical point, there is the possibility that just one additional grain results in the avalanching collapse of the whole pile. In a phase of SOC, the effects of one additional element vary from small to large, either pushing the system into chaotic behaviour or locking it into a fixed behaviour. The system is on the “edge of chaos”. One feature that characterises SOC-systems is a power law distribution of the characteristic events such as avalanches, quakes, crashes, etc.: The average frequency of the event is inversely proportional to some power of its size: $\log(F) = -\log(M)$. The log of the frequency of events is a linear function of the log of their magnitudes. The theory of SOC assumes that SOC patterns can be found e.g. in wars, wildfires, stock prices, traffic jams, international conflicts, and the collapse of society (Brunk 2002).

Almost everywhere in chemistry one can find examples for the transition from quantity to quality, therefore Engels speaks of chemistry as “science of the qualitative changes of bodies as a result of changed quantitative composition“ (Engels 1886a: 351). This transition is what today is called in self-organisation theory emergence⁹. In a self-organising system, a certain threshold of a control parameter is crossed and order emerges. What is today called a point of

⁹ Geoffrey Hodgson (2000: 65) points out that the concept emergence was anticipated by the philosophies of Hegel and Marx/Engels: “The terms ‘emergence’ and ‘emergent property’ date from the last quarter of the nineteenth century. However, the general idea behind these terms is older. It is redolent, for example, of the ‘law of the transformation of quantity into quality’ laid down by G.W.F. Hegel in his *Logic* and subsequently taken up by Karl Marx and Frederick Engels“.

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bifurcation, instability or criticality, Engels refers to as “Hegelian nodal line of measure relations – in which quantitative change suddenly passes at certain points into qualitative transformation“ (Engels 1878: 117) or even directly anticipating the modern terminology he speaks of “critical points“ (Engels 1886a: 351). As other examples for nodal lines Engels mentions e.g. a certain current strength that is required to cause the platinum wire of an electric incandescent lamp to glow, the temperature of incandescence and fusion of metals, the freezing and boiling points of liquids, the critical point at which a gas can be liquefied by pressure and cooling (Engels 1886a: 351). The transition from quantity to quality that occurs e.g. in the homologous series of carbon compounds when certain atoms are added can also be termed the emergence of a qualitatively different body.

Other examples that Engels mentioned for the transition from quantity to quality and that could equally be described as the emergence of new qualities in a critical situation after a threshold of a certain control parameter has been crossed, include:

change of form of motion and energy: “All qualitative differences in nature rest on differences of chemical composition or on different quantities or forms of motion (energy) or, as is almost always the case, on both. Hence it is impossible to alter the quality of a body without addition or subtraction of matter or motion, i.e. without quantitative alteration of the body concerned. [...] Change of form of motion is always a process that takes place between at least two bodies, of which one loses a definite quantity of motion of one quality (e.g. heat), while the other gains a corresponding quantity of motion of another quality (mechanical motion, electricity, chemical decomposition). Here, therefore, quantity and quality mutually correspond to each other“ (Engels 1886a: 349)

Engels refers to Hegel’s example of the states of aggregation of water (Engels 1886a: 351): “Thus the temperature of water is, in the first place, a point of no consequence in respect of its liquidity: still with the increase or diminution of the temperature of the liquid water, there comes a point where this state of cohesion suffers a qualitative change, and the water is converted into steam or ice“ (Hegel 1874: §108). As other examples Hegel mentions the reaching of a point where a single additional grain makes a heap of wheat; or where the bald-tail is produced, if we continue plucking out single hairs.

For Engels “the negation of the negation is an extremely general [...] law of development of nature, history, and thought; a law which, as we have seen, holds good in the animal and plant kingdoms, in geology, in mathematics, in history and in philosophy“ (Engels 1878: 131).

As an example from nature he mentions the development process of a grain of barley: “Billions of such grains of barley are milled, boiled and brewed and then

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consumed. But if such a grain of barley meets with conditions which are normal for it, if it falls on suitable soil, then under the influence of heat and moisture it undergoes a specific change, it germinates; the grain as such ceases to exist, it is negated, and in its place appears the plant which has arisen from it, the negation of the grain. But what is the normal life-process of this plant? It grows, flowers, is fertilised and finally once more produces grains of barley, and as soon as these have ripened the stalk dies, is in its turn negated. As a result of this negation of the negation we have once again the original grain of barley, but not as a single unit, but ten-, twenty- or thirtyfold“ (Engels 1878: 126). As similar examples he mentions the development process of insects, geology as a series of negated negations, a series of successive chatterings of old and deposits of new rock formations, differential and integral calculus, the development of philosophy and society. These development processes can also be described in the terms of physical self-organisation: the control parameters that influence the development of the grain are time and natural conditions such as heat and moisture. During this development new seeds will show up. At a specific point of time, a critical point is reached and the grain ceases to exist. But at the same time new grains emerge.

Dialectical processes and negation of the negation not just only mean the emergence of other, new qualities, dialectic development also includes development process that results in *higher* qualities and other structural levels. Dialectical development is not just change or self-transformation and self-reproduction, it is also the emergence of higher levels of organisation (Hörz 1976: 311ff). Hence dialectical thinking assumes an immanent hierarchy in nature and evolutionary leaps.

This was also pointed out by Engels: “The transition from one form of motion to another always remains a leap, a decisive change. This is true of the transition from the mechanics of celestial bodies to that of smaller masses on a particular celestial body; it is equally true of the transition from the mechanics of masses to the mechanics of molecules – including the forms of motion investigated in physics proper: heat, light, electricity, magnetism. In the same way, the transition from the physics of molecules to the physics of atoms – chemistry – in turn involves a decided leap; and this is even more clearly the case in the transition from ordinary chemical action to the chemism of albumen which we call life. Then within the sphere of life the leaps become ever more infrequent and imperceptible“ (Engels 1878: 61).

Self-organisation theory is also dialectical in the respect that it frequently considers self-organisation as emergent evolution. This means that there are different hierarchical organisational levels of self-organisation that differ in complexity and

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where new qualities of organisation emerge on upper levels. In self-organisation theory e.g. Ervin Laszlo (1987) argues that evolution does not take place continuously, but in sudden, discontinuous leaps. After a phase of stability a system would enter a phase instability, fluctuations intensify and spread out. In this chaotic state, the development of the system is not determined, it is only determined that one of several possible alternatives will be realised. Laszlo says that evolution takes place in such a way that new organisational levels emerge and identifies the successive steps of evolution. Not all scientists who speak about self-organisation include the development of higher qualities into their concepts. Hence dialectical materialism can in this respect be considered as a broader evolutionary concept than self-organisation.

3. Autopoiesis: Cognition as Construction and/or Reflection?

One of the central issues in epistemology today is whether cognition is a construction or a reflection. I first want to make some comments on the materialistic theory of reflection, then I will take a look at the epistemological implications of autopoiesis theory, and will argue that a materialistic interpretation of autopoiesis is possible.

Already Lenin pointed out that reflection is a quality of matter (Lenin 1952: 82) and his description of matter is connected to this notion of reflection: "Matter is a philosophical category denoting the objective reality which is given to man by his sensations, and which is copied, photographed and reflected by our sensations, while existing independently of them" (ibid.: 118f). Taken as an isolated statement, this description is problematic because it can invoke the impression that 1. cognition is only a passive process, not also an active one that is the foundation of transformative human practice, 2. that there is a linear, fully determined reflection of outside reality within a material system, i.e. no autonomy and degree of freedom is granted to the category that is considered as the one being determined by a determining instance. This would be a position of naive, mechanistic realism and a dualistic concept because it wouldn't consider consciousness as a specific organisational form of matter, but would see it as something external to matter (that nonetheless depends on the latter). Such a description would indeed suggest that subjectivity is not material, idealists or spiritualists could agree with it. E.g. Aristotle or Thomas d'Aquin said that God is an extra-mental, immaterial reality. But one can doubt as I will show that this was really Lenin's intention. Concerning the first point it can be argued that in the works of Marx and Engels there is much emphasis on freedom that can be achieved by human practice in class struggles. Arguably also Lenin put much emphasis on human practice, hence it is unlikely that he only saw cognition and the actions that are based in it as passive processes.

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Concerning the second point one must say that one finds quite some unfortunate formulations in the philosophical works of Lenin as well as of Engels that can create the impression that they wanted to put forward a mechanistic theory of knowledge. In Lenin's "Materialism and Empirio-Criticism" (1952) there are indeed a number of problematic formulations that can create the impression that cognition produces mechanically an identity between objective reality and sensations. The problem is that Lenin describes reflection sometimes as copies, images, and photographs (see pp. 15, 59, 92, 99, 103f, 118f, 224, 255)¹⁰. Engels provided an important foundation for a materialist theory of knowledge by pointing out that the great basic question of all philosophy is that concerning the relation of thinking and being (1886b: 338). But he also left many questions open and some of his formulations were later interpreted in mechanistic manner. E.g. he pointed out that the overwhelming majority of philosophers give an affirmative answer to the question if there is an identity of thinking and being (339), said that the thoughts in our heads are "images [Abbilder] of real things" (355) and spoke of "mind images in our heads" (ibid.). The problem is that both Engels and Lenin didn't give an exact description of reflection and consciously used drastic formulations and technological metaphors in order to stress the difference between their position and idealism and empiricism.

But one can also find passages in Lenin's works where he points out that his theory of reflection is not based on the naïve realistic assumption of identical reproduction of the outside world in thoughts (which by the way would mean that all human beings were independently from the social circumstances highly prone to manipulation and could be characterised by an almost full degree of homogeneous thoughts). So the question arises what Lenin exactly means when he speaks of mental reflections, pictures or images of things (Lenin 1952: 30f). The following quotations show that the essence of Lenin's theory of reflection is that objective reality exists outside and independent of human beings and that reflection means only that material reality causes sensations. Material reality is objective in the sense that it existed prior to humans and society, that it is endlessly changing and produces different organisational levels of matter. The human being and its consciousness form one of these levels that is based on interaction and exchange of matter between external world and the body (Lenin 1952: 32f). The materialistic

¹⁰ E.g.: "Materialism is the recognition of "objects in themselves," or outside the mind; ideas and sensations are copies or images of those objects" (15). "Our sensation, our consciousness is only *an image* of the external world, and it is obvious that an image cannot exist without the thing imaged, and that the latter exists independently of that which images it" (59).

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views “do not consist in deriving sensation from the movement of matter or in reducing sensation to the movement of matter, but in recognising sensation as one of the properties of matter in motion” (36). “1) the physical world exists *independently* of the mind of man and existed long *prior to* man, *prior to* any “human experience”; 2) the psychical, the mind, etc., is the highest product of matter (*i.e.*, the physical), it is a function of that particularly complex fragment of matter called the human brain” (217). “This is materialism: matter acting upon our sense-organs produces sensation. Sensation depends on the brain, nerves, retina, etc., *i.e.*, on matter organised in a definite way. The existence of matter does not depend on sensation. Matter is primary. Sensation, thought, consciousness are the supreme product of matter organised in a particular way” (44). “Matter is primary, and thought, consciousness, sensation are products of a very high development. Such is the materialist theory of knowledge, to which natural science instinctively subscribes” (64).

Lenin wants to stress the primacy of matter, material reality would *evoke* sensations and thoughts in our brains, but not determine the exact content of these thoughts. The following quotation shows that when Lenin speaks of reflection as the production of images of reality he means nothing more than “the existence of things outside our mind, which, by acting on our sense-organs evoke sensations” (102, similarly p. 154): “Sensation is the result of the action of a thing-in-itself, existing objectively outside us, upon our sense-organ – such is Feuerbach’s theory. Sensation is a subjective image of the objective world, of the world *an und für sich*” (108).

Lenin indeed explicitly mentions that there is no absolute identity between thoughts and material reality and that they are to a certain extent different: He says that the “objective connection of the phenomena of nature” can be reflected “only approximately” (Lenin 1952: 145) and that “reflection [...] is, of course, approximate” (54). “The objects of our ideas are distinct from our ideas, the thing-in-itself is distinct from the thing-for-us, for the latter is only a part, or only one aspect, of the former, just as man himself is only a fragment of the nature reflected in his ideas” (107). ““Social being” and “social consciousness” are not identical, just as being in general and consciousness in general are not identical. From the fact that in their intercourse men act as conscious beings, it *does not follow* that social consciousness is identical with social being. [...] Social consciousness *reflects* social being—that is Marx’s teaching. A reflection may be an approximately true copy of the reflected, but to speak of identity is absurd” (313f).

Also Engels pointed out that reflection should be understood not as the mechanical production of an identity between thoughts and outside reality. He said that there

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are “necessary limitation of all acquired knowledge, of the fact that it is conditioned by the circumstances in which it was acquired. [...] Everything which sets men in motion must go through their minds; but what form it will take in the mind will depend very much upon the circumstances” (Engels 1886b: 356, 360f). We hence should understand reflection only as reactions evoked by material reality in the brain: “The influences of the external world upon man express themselves in his brain, are reflected therein as feelings, impulses, volitions” (Engels 1886b: 345).

So the materialist theory of knowledge as founded by Engels and Lenin indeed is no mechanistic theory, but stresses that the human being and consciousness form an organisational level of matter and that thinking is only possible as a material, practical activity of the human being where there are material input and output flows from and to the natural and social environment that are taken up resp. transmitted by the sense-organs and cause sensations, emotions and experiences in the brain. Harsh philosophical conflicts provoked harsh and misleading formulations by Engels and Lenin. Engels pointed out that the following questions are central for a theory of knowledge: “In what relation do our thoughts about the world surrounding us stand to this world itself? Is our thinking capable of the cognition of the real world? Are we able in our ideas and notions of the real world to produce a correct reflection of reality?” (Engels 1886b: 339). The answer clearly is: Yes, the human being can recognise the world and makes (scientific and practical) efforts for approximating truth. But there is no *automatic* correct reflection of reality, the content of our thoughts depends on many internal and external influences, there is always a certain degree of chance and freedom in thinking that is enabled and constrained to certain extents by the objective material conditions of society. The natural and social environment permanently *evokes* human thoughts, human knowledge itself is not absolute, but depends on the complex interactions of circumstances and hence has limitations and a certain degree of indeterminacy. Thoughts are complexly evoked by the reality of nature and society in a non-linear process, they *resemble* depending on the degree of human progress of society to a certain degree objective reality, but are not identical with the outside environment.

However, it is not true as Lenin (1952) indicated in some passages that there is a linear progress in human knowledge. He said that “incomplete, inexact knowledge becomes more complete and more exact” (92) and that “reflections become more and more faithful” (300). Scientific progress would allow an increasing approximation to objective truth. “From the standpoint of modern materialism i.e., Marxism, the *limits* of approximation of our knowledge to objective, absolute truth are historically conditional, but the existence of such truth is *unconditional*, and the

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fact that we are approaching nearer to it is also unconditional. The contours of the picture are historically conditional, but the fact that this picture depicts an objectively existing model is unconditional. When and under what circumstances we reached, in our knowledge of the essential nature of things, the discovery of alizarin in coal tar or the discovery of electrons in the atom is historically conditional; but that every such discovery is an advance of “absolutely objective knowledge” is unconditional” (125). Such arguments are clearly an expression of the technological and scientific optimism characteristic for the beginning of the 20th century. Today we live in a phase of capitalism that can be characterised as a high-risk society: technology has a very ambivalent character, it causes at the same time great possibilities and great risks (cf. Fuchs/Hofkirchner 2003 and Hofkirchner/Fuchs 2003). Computerisation and scientific advancements have resulted in a paradox situation where the large development of the productive forces has produced objective material conditions that would enable an immediate transition towards a free society without hard work and exploitation, but at the same time these forces act as destructive forces that tremendously contribute to the enlargement of control, destruction, and heteronomy (Fuchs 2002h, d). We face a condition where both a free society and the destruction of humankind are possibilities, the outcome depends on human practice in class struggle. This paradox situation also means that there is no automatic approximation towards truth and absolute knowledge, indeed the high-risk character of modern society results in permanent advancements of scientific and practical knowledge, but this knowledge massively produces non-knowledge and risks that must be mastered. We today have increased possibilities for approximating absolute truth and societal wisdom, but also increased possibilities for going many steps backwards instead of forward or even annihilating all possibilities for human progress.

Mechanistic determinism argues that causes and effects can be mapped linearly: each cause has one and only one effect, similar causes have similar effects, different causes have different effects; one assumes that small changes of causes necessarily have small effects and large changes of causes necessarily have large effects. Meanwhile the sciences of complexity have shown that similar causes can have different effects and different causes similar effects; small changes of causes can have large effects whereas large changes can also only result in small effects (but nonetheless it can also be the case that small causes have small effects and large causes large effects). When thinking the relationship of a system and its environment dialectically and in terms of the modern sciences of complexity, the notion of reflection shouldn't be defined in a strictly deterministic manner, there should be room for a dialectic of chance and necessity. This can be achieved within a general theory of self-organisation.

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By pointing out that one could see reflection as a general quality of matter, Lenin has anticipated interpreting reflection as a general characteristic of self-organising systems. In all self-organising (physical, biological, and social) systems the emergence of order is triggered by fluctuations that cause synergies between the elements of the systems. One can say that influences on the system are reflected within the system, i.e. new order and patterns emerge that can't be reduced to single elements, but are caused by synergetical interactions. There is a non-linear, complex relationship between causes and effects in self-organising systems: It is objectively conditioned that a fluctuation will at some critical point in the system's development result in the emergence of new order (necessity). But the exact moment and the exact form of the process of emergence and its resulting new qualities is to a large degree uncertain (chance). Reflection means a complex causal relationship between an entity that causes changes, the system within which these changes take place, and the realisation of these changes within the further development of the system. This broad understanding of reflection has to do with the fact that all self-organising systems are information-generating systems (Fleissner/Hofkirchner 1996, 1997).

Information is a relationship that between specific organisational units of matter. Reflection (*Widerspiegelung*) means reproduction of and reaction as inner system-changes to influences from the outside of a system. There is a causal relationship between the result of reflection and the reflected. The reflected causes structural changes, but doesn't mechanically determinate them. There is a certain, relative autonomy of the system, this autonomy can be described as a degree of freedom from perturbations. On the different organisational levels of matter we find different degrees of freedom. This degree increases along with complexity if we go up the hierarchy from physical-chemical to living and finally social systems. The causal relationship between the reflected and the result of reflection is based on a dialectic relationship of freedom and necessity. Information is an objective relationship between the reflected, the result of reflection inside the system's structure and the realisation of functions of the system within the reflected environment of the system (see Hörz/Röseberg 1981: 273ff). This means that information is a relationship of reflection between a system and its environment, to be more precise between units of organised matter. Information is not a structure given in advance, it is produced within material relationships. "Information is a physical structure and at the same time a structure which dominates the physical forces. [...] Information is not a physical substance, it is instead temporarily 'attached' to it. Information must be understood as a specific effect and as a relationship" (Fuchs-Kittowski 1997: 559f).

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When two systems interact, they enter an objective relationship, i.e. a (mutual) causal relationship is established (Fuchs 2003e, f). This is a relationship of reflection that is based on cognition, communication, and co-operation: A portion of subjective, systemic information (“*cognition*”) is communicated from system A to system B (and vice versa, “*communication*”). This causes structural changes in the other system. If there is an information relationship between the two systems, it is determined that there will be causal interactions and structural effects, i.e. reflection. The structure of the systems (structural, subjective information) changes, but we don’t know to which extent this will actually be the case, which new subjective information will emerge, which information (structures) will be changed etc. There are degrees of autonomy and freedom (=chance). If structural changes in system B take place and are initiated by system A, this means an objectification of subjective information of A in B from the point of view of A. From the point of view of B it means subjectification of objective information from the environment. In a communication process, this also takes place the other way round. By communication it can not only be the case that an objectification of information in some of the involved systems takes place, it can also be the case that due to the synergies between the systems new qualities (information) emerge in their shared environment (“*co-operation*”). Structural, subjective information of the involved systems is co-ordinated, synergies arise and hence something new is produced commonly in a self-organisation process. The new structure or system that arises is an objectification of subjective information of the involved systems. Information in self-organising systems has cognitive (subjective), communicative (new subjective information (=structures) emerges in systems due to interaction) and co-operative aspects (interaction results in synergies that cause the emergence of new, objectified information in the shared environment of the involved systems) (Fuchs 2003 e,f).

Biology has long struggled for finding a consistent definition of life. Such definitions normally include a list of properties such as movement, metabolism, replication, sensation, reaction to stimuli, growth, ageing, disease, death, reproduction, regulation, inheritance. The problem is that always examples can be found that don’t seem to fit the property lists. Humberto Maturana and Francisco Varela (1992) have tried to find a consistent definition of life, they say that living systems are biologically self-organising ones, i.e. the permanently produce themselves. They call such self-producing systems autopoietic (autos=self, poiein=to make something).

Autopoietic systems or biological self-organisation can be characterised by the following items:

1. They permanently produce their parts and their unity themselves

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2. An autopoietic organisation is characterised by relations between its parts
 3. These relations result in a dynamic network of interactions
 4. Autopoietic systems are operationally closed: the effects of the network of interactions don't go beyond the network itself
 5. The autopoietic unit forms its own border, it delimits its structure from its environment. In a cell the membrane is such a border.
 6. The production of the system's components enables the forming of a border, a border is a precondition for a dynamic that is needed for the self-production of the system (circular causality)
 7. Living systems constitute themselves as different from their environment, they are autonomous units.
 8. Structural coupling: Perturbations from the environment can influence an autopoietic unit, but it can't fully determine changes of the system's structure
- The main characteristics of an autopoietic system are self-maintenance, self-production and production of its own border.

In his *Anti-Dühring* and his *Dialectics of Nature*, Friedrich Engels pointed out the problem of defining life and intuitively anticipated the theory of autopoiesis. Of course today we know a whole lot more about life than Engels did, especially since the discovery of the double helix. But what's important is that Engels anticipated the idea of autopoiesis, he says that life exists in the "constant self-renewal of the chemical constituents" it has (Engels 1878: 75), life is a "self-implementing process" (ibid.: 76), albumen would not only permanently decompose itself, it would also permanently produce itself from its components (Engels 1876a: 558f).

Robert Steigerwald (2000) in his essay on "Materialism and the Contemporary Natural Sciences" also concludes that modern scientific theories like the theory of self-organisation affirm the topicality of dialectical materialism and cause problems for idealistic worldviews. Concerning autopoiesis he has warned against the epistemological consequences of this theory that have frequently resulted in solipsism. People like Maturana, Varela, von Foerster, von Glasersfeld, and Luhmann have indeed argued within their epistemological framework of radical constructivism that one should interpret autopoiesis theory in such a way that the brain is an autonomous system, that hence there is no objective reality, only subjectively constructed realities. The whole world would be a construction. Such an epistemology doesn't comply with the realistic materialist assumption that the material world forms an objective reality that exists independently of our thinking. Radical constructivism is inherently solipsistic and is a form of subjective idealism. It is striking nonsense to assume e.g. as many constructivists do that the flower that I see only exists in my thoughts, but not independently from it.

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Autopoiesis as an ontological principle describes the *differentia specifica* of living (biological) self-organising material systems. It is a mistake to assume that autopoietic systems are closed, fully autonomous systems; permanent material inputs and outputs to our body are a fundamental and necessary condition for autopoiesis. Autopoietic systems are like all self-organising systems open systems that exchange matter with their environment in order to organise themselves, its misleading to argue that they are closed systems (cf. Collier 2003). The brain and the other organs of the human body are self-organising in the sense that based on material inflows and outflows they can maintain and reproduce themselves. When Maturana speaks of structural coupling of an autopoietic system to its environment in the sense that perturbations from the environment can influence an autopoietic unit, but can't fully determine changes of the system's structure, this reminds us of Engels' and Lenin's theory of knowledge where the material environment of a human body that exists independently of this body evokes sensations and thinking, but doesn't produce an identity or exact mapping between thinking and being. Understood in such a way, autopoiesis theory indeed confirms dialectical materialism, but one must admit that the dominant interpretation of this theory is an idealistic and solipsistic one.

Cognition means neither autonomous construction, nor mechanistic reflection. The materialistic theory of knowledge has shown that cognitive systems are a specific form of self-organising matter and that the natural and social material environment of a human being is a necessary foundation of cognition. Systems in the environment of a human being permanently cause material data flows that are received by the sense-organs of a particular human being. It is determined that such a reflection takes place permanently, it is not exactly determined which interpretations and actions this reflection will have, only that it will cause changes of the cognitive structural patterns. The external material data is perceived, interpreted and incorporated in an autopoietic process. Cognition is not a passive process, the individual takes actively part in its environment and together with others practically changes this environment. The material flows that result in social interaction and in interaction with the natural world result in an active construction of thinking by the individual. Construction here means that the formation of cognition is influenced by an individual's active participation in its environment and its practical appropriation of nature. Cognition is neither fully determined nor fully undetermined, the social and natural life world condition a field a possibilities of cognitive patterns in a certain situation. Which possibility is selected in a certain situation depends on the individual's history of experiences, its learned patterns of thinking and action, its habitus, its class situation and the complex interplay of outside factors and the individual.

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Cognition is both construction and reflection in the sense that the individual actively participates in those conditions that it reflects. Hence in my view a concise materialist epistemology should be a position of constructive reflection (konstruktive Widerspiegelung). Information has subjective as well as objective aspects. It is on the one hand a property of cognitive systems, a difference that makes a difference, and as such it is selected in the communicative process which can be considered as Niklas Luhmann (1984) has shown as an emergent synthesis of three selections (selection of information, uttering and understanding). Due to the selectivity of the communication process, information has a certain degree of uncertainty. On the other hand information is also an objective, reflective social relationship: If actors communicate or an actors interacts with the natural environment, information exists as an objective relationship and this relationship involves reflection. Reflection (Widerspiegelung) doesn't mean the mechanical reproduction of data by a receiver, it only means that in the case of communication there is a reaction of one communication partner to the symbolic actions of the other partner. It is determined that he reacts and in this reactions he makes uses of symbols, otherwise one couldn't speak of communication or interaction. But it is not determined how he reacts exactly, this is relatively open, but frequently also to a certain extent predictable due to certain regularities of behaviour that can be found in the social world. Such reflective reactions are neither completely determined, nor completely undetermined, their causality can be characterised as relative chance and incomplete determinism. Such objective information relationships occur milliards of times per day relatively stable, hence information as a social relationship is relatively probable. However there are degrees of uncertainty due to different dispositions, norms, values, habitus, cultural contexts, interpretative schemes, tastes, life-styles etc. of the partners in a communicative setting.

Information exists in all social relationships, but it has different effects. We neither photographically and mechanically map knowledge, nor are we autonomous knowledge producers. Due to certain normative dispositions certain reactions and interpretations to a stimulus are more probable than others. But the human being is a being that can change his views during productive discourses , hence social information relationships not only increase the knowledge of a subject, they also result in a (faster or slower) differentiation of definitions. Human interpretation is neither mechanical mapping, nor coincidental construction, but constructive reflection. Reflection involves reaction to external stimuli during the course of communications where different alternative interpretations and behaviours are possible. It depends on the degree of participation and democratisation of society to which extent interpretation and critical reflection are activated.

4. Sociological Implications of Self-Organisation Theory

Robert Steigerwald (2000) has asked important questions about the philosophical and sociological implications of self-organisation theory: “Does this conception of evolution not also imply the impossibility of predicting the future development of social systems, since at such a bifurcation point the system staggers, fluctuates, tries to replace the old order by a new one, but with no certainty about what will be chosen? Does this not disprove the materialist historical conception that socialism is the system that follows capitalism?”. Social self-organisation happens to be one of my main areas of research, hence I want to give some comments on the sociological implications of self-organisation, but for more details I have to refer the reader to a number of other works (Fuchs 2001; 2002a-c, f-g; 2003a-f, Fuchs/Hofkirchner 2002, Fuchs/Hofkirchner/Klauninger 2001, Fuchs/Schlemm 2002, Fuchs/Stockinger 2002).

Nature is the foundation of society, there is a dialectical mutual coupling between nature and society. It is a false inference to directly transfer principles of physical and biological self-organisation to the societal realm. Hence one must on the one hand philosophically point out general principles of self-organisation that apply to all systems and on the other hand provide for each system type also the differentia specifica of its self-organisation. Human systems differ in a number of respects from other systems, the human being is as Marx has shown the central aspect of societal change (Fuchs 2002b, Fuchs/Schlemm 2002).

Marx pointed out that man like animals lives from inorganic nature, he must remain in a continuing physical dialogue with nature in order to survive. Animals produce only when immediate physical need compels them to do so, the human being actively and consciously identifies and tries to reach goals by producing means with which he appropriates and changes nature. The breakage of immediacy that constitutes goal-oriented, conscious production distinguishes the human being from animals. In the production of his life which includes the metabolism between society and nature and societal reciprocity, man as the universal, objective species-being produces an objective world (gegenständliche Welt) and reproduces nature and his species according to his purposes (Marx 1844a).

The individual is a societal, self-conscious, creative, reflective, cultural, symbols- and language-using, active natural, labouring, producing, objective, corporeal, living, real, sensuous, anticipating, visionary, imaginative, expecting, designing, co-operative, wishful, hopeful being that makes its own history and can strive towards freedom and autonomy (cf. Fuchs 2002b, Fuchs/Schlemm 2002). The human beings has the ability to consciously create together with others new

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realities and environments. Social self-organisation in a broad synchronous sense means permanent reproduction of a social system in a process that permanently connects social structures and actors (cf. Fuchs 2002b, 2003a, b). Social structures enable and constrain actions, they are medium and outcome of social actions. This reflexive process is termed re-creation and describes the synchronous process of social self-organisation. Social systems are re-creative systems. The overall self-reproduction of society is not a smooth, permanently stable process, it is in constant flux and from time to time enters phases of crisis. Hence social self-organisation can in a second, diachronic sense also be understood as being based on the principle of order through fluctuation (cf. Fuchs 2002c, 2003c). Crises are periods of instabilities where the further development of the overall system is not determined. In modern, capitalist society, periods of crisis are caused by developing structural antagonisms. Concerning the evolution of a specific mode of capitalistic development, we find a dialectic of chance and necessity: It is determined that the development of the mode will sooner or later result in a large societal crisis, but it is not fully determined which antagonisms will cause the crisis, when it will take place, and how the result of the crisis will look like.

Is our behaviour determined by social structures? Or can we freely decide how to change these structures? Or can both views be integrated dialectically? Possibly, in phases of instability, social chaos and crisis, social actions are very important and influence the further development greatly. In such situations, small causes can have great effects. It is rather determined that a system like capitalism enters crisis and phases of instability periodically. But the outcome, the concrete course and point of time is left to chance, i.e. it is determined by human agency. The global crisis we are witnessing today is due to the culmination of the antagonisms of capitalism which are all based on the fact that certain groups are included into the conditions of wealth, participation and decision-making whereas others are excluded from it. The material reality of society, i.e. the social forces and relationships, conditions a field of possible future developments, i.e. not everything is possible at any time. Which possibility will be realised in a situation of crisis and high fluctuations is not predetermined, it depends on human practice and the outcome of class struggles. Fundamental social change for the better is neither a necessity nor impossible, the theory of self-organisation shows us that the decisive fact is that it is a possibility and that active human practice is the decisive factor of change. The probability of realising this possibility is not determined, it depends on our responsibility.

Marx was misunderstood by many and interpreted in such a way that he put forward a linear, deterministic stage model of societal development. But indeed there was so much emphasis on practice in Marx's works. The active human being is the greatest productive force, future developments are conditioned by objective

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material relationships and forces, but determined by class struggle. The question whether or not capitalism will be followed by socialism can be answered by saying that the capitalistic development of the productive has conditioned the material possibility for a higher type of society, but there is no automatic realisation of this possibility. 100 years from now society could either no longer exist at all due to the continued development of destructive forces, we could still be living in a capitalist society that probably would be a highly militarised, unjust and repressive type of regime or we could indeed be living in a fully democratic and participatory society. These are possibilities that have been conditioned by the development of capitalism that has resulted in today's large societal crisis. The theory of self-organisation shows us that there is hope for positive change, but this hope must be active, transformative hope.

5. Conclusion: Science, Materialism and Religion

As Engels implicitly pointed out, the substance of the world is its process-character, the permanent dialectical movement of matter and the productivity of matter that results in self-reproduction and the emergence of new, higher qualities and organisational forms of matter. This corresponds to saying that the substance of the world is the permanent self-organisation of matter. As has been shown, processes of physical self-organisation can be described in dialectical terms. Control parameters, critical values, bifurcation points, phase transitions, non-linearity, selection, fluctuation and intensification in self-organisation theory correspond to the dialectical principle of transition from quantity to quality. What is called emergence of order, production of information or symmetry breaking in self-organisation theory corresponds to Hegel's notions of sublation (*Aufhebung*) and negation of the negation. The concept of emergent evolution corresponds to the principle of dialectical development, the dialectics of chance and necessity as well as of attraction and repulsion that have been described by Hegel, Engels and Marx are constitutive for processes of self-organisation. The other way round, the examples Engels gave for the dialectics of nature can also be seen as examples of the self-organisation of matter.

Self-organisation theory shows that Engels' *Dialectics of Nature* is still very topical and that dialectical materialism contrary to mechanical materialism hasn't been invalidated, it rather seems to be confirmed that dialectics is the general principle of nature and society. Self-organisation theory lines out Engels' assumptions that the real unity of the world consists in its materiality, that matter is process-like and in constant flux, that it is a producing entity that is uncreateable and indestructible. That the substance of the world is self-organisation of matter which results in higher organisational forms of matter, thus far the highest

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organisation form is human society, means that God doesn't exist, that there is no creatio-ex-nihilo and no first mover that isn't moved itself. Hence religion and esoteric thinking are mere ideology, false consciousness. Dialectical materialism seems to be confirmed by modern science, whereas serious problems arise for idealistic worldviews. "The conceptions of self-organisation, the conceptions that assign a determining role to the activity of inner factors instead of outer, are new scientific affirmations of the old dialectical theses, as well as the conceptions of the general connection of all things and appearances" (Steigerwald 2000). Self-organisation theory is indeed a dialectical materialist-theory, but unfortunately its representatives not all too often realise this and don't acknowledge the dialectical tradition and heritage of the philosophy of nature in the line of Friedrich Engels and Karl Marx.

The natural sciences that emerged during the last century such as quantum theory, quantum mechanics, first and second order cybernetics, general system theory, non-equilibrium thermodynamics, synergetics, dissipative systems theory, autopoietic systems theory, catastrophe theory, punctuated equilibrium theory, hypercycle theory, string theory, loop theory etc. deal with the ontology of the material world. Hence there seems to be scientific evidence that nature is a self-organising totality and is its own cause. This seems to confirm the materialist notion that matter is uncreateable and indestructible.

20th century science seems to indicate that the assumption that dialectical development is a universal law of nature and that dialectical materialism is right, but frequently human consciousness lags behind the progress of science, technology and society. Linked to the current crisis of the capitalist world system there is a tendency of mysticism and irrationalism spreading in society. This tendency also affects the scientific community.

It is quite common today in idealistic thinking to interpret the big bang as the creation of the world by God where nothing turns into something. But if before the big bang there was nothing except God, what is the foundation of God? There has never been scientific evidence that God could really exist as an eternal substance outside of material existence and that he is his own reason, whereas modern science has produced evidence that matter is *causa sui*, organises itself and hasn't been created by an external first mover out of nothing. It is not reasonable to assume that the world has been created out of nothing by God and that God really exists. In such arguments a causal principle is applied to matter, but the same causal principle is declared as not holding for God. There are no rational reasons why this should be the case. Talking about God and the origin of the world means

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talking about universality, it's unreasonable to apply a form of universal causality to one universal phenomenon, but to simply ignore it for another one.

Accepting the big bang theory normally means to accept that matter, space, time haven't existed prior to this event and that they have been created out of nothing. This assumption has been welcomed by idealists and most world religions. Stephen Hawking has reported that the pope told him and other scientists that it is ok to study the evolution of the world after the big bang, but that they shouldn't research what and if something existed prior to it. Hubble discovered that galaxies are moving away from us, Friedmann and Lemaitre inferred from this that the universe is not only expanding, but must have once been a compressed nucleus ("cosmic egg"). One of the latest version of big bang theory is the inflation theory by Alan Guth who says that the universe at first was a small nucleus and right after the big bang expanded at unimaginable speed, doubling in size every 10 to 35 seconds. Big bang theory certainly poses questions that it can't answer easily: How can one pack the infinite size of the universe into a finite small point? What existed before the big bang? How can there be a material explosion without matter existing prior to it? "From the standpoint of dialectical materialism, it is arrant nonsense to talk about the 'beginning of time', or the 'creation of matter'. Time, space, and motion are the mode of existence of matter, which can neither be created nor destroyed. The universe has existed for all time, as constantly changing, moving, evolving matter and (which is the same thing) energy" (Woods/Grant 2002: 193). The big bang theory is indeed a "modern Creation myth" that allows mysticism as well as religious and idealistic thinking to permeate science. The aim of science is the formulation of explanations for that which we do not yet know, explanations which are derived from material reality themselves. Big bang theory puts limits to science, introduces questions that shouldn't be asked and explained immanently. It is so attracting for mystical thinkers because it allows them to give answers that refer to an external outside of material reality. "Today Big Bang theorists see a universe much like that envisioned by the medieval scholars – a finite cosmos created ex nihilo, from nothing, whose perfection is in the past, which is degenerating to a final end. The perfect principles used to form this universe can be known only by pure reason, guided by authority, independent of observation. Such a cosmic myth arises in periods of social crisis or retreat, and reinforces the separation of thought and action, ruler and ruled. It breeds a fatalistic pessimism that paralyzes society" (Lerner 1981).

That the universe is expanding doesn't necessarily mean that its whole has been created by a big bang that is singular in character and stands at the beginning of the history of the universe. In fact there are alternative cosmological theories and hypotheses. It could be the case that the explosion took place, but only as an

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explosion in a small part of the universe due to the combination of matter and antimatter (Hannes Alfvén). Alfvén (1981) suggested that the galaxy contains a large-scale magnetic field and that the cosmic rays move in spiral orbits within the galaxy, owing to the forces exerted by the magnetic field. He said that there could be a magnetic field pervading the entire galaxy if plasma was spread throughout the galaxy. He assumed that due to the fact that the universe is overwhelmingly made up of plasma, plasma phenomena shape the evolution of the universe. This plasma could carry the electrical currents that would then create the galactic magnetic field. Alfvén considered the big bang theory as a myth devised to justify creation. He assumed and tried to show that plasma phenomena (large currents and magnetic fields) shape the evolution of the universe. He pointed out that in his view an explosion in one part of the universe caused by particles that were trapped in magnetic fields resulted in a huge expansion of plasma.

It could also be the case that there can be expansion of certain parts and contraction of other parts of the universe at the same time.

Paul J. Steinhardt and Neil Turok suggest that the evolution of the universe takes place in cycles of expansion and compression and that hence it hasn't been created and won't be destroyed, but exists eternally. "The cyclic model is a complete model of cosmic history, whereas inflation is only a theory of cosmic history following an assumed initial creation event. Hence, the cyclic model has more explanatory and predictive power" (Steinhardt/Turok 2002). According to this theory "space and time exist forever, the big bang is not the beginning of time; rather, it is a bridge to a pre-existing contracting era, the Universe undergoes an endless sequence of cycles in which it contracts in a big crunch and re-emerges in an expanding big bang, with trillions of years of evolution in between" (Steinhardt 2002). It addresses many questions that the big bang and inflationary model don't answer: "What occurred at the initial singularity? What is the ultimate fate of the Universe? What is the role of dark energy and the recently observed cosmic acceleration? Does time, and the arrow of time, exist before the big bang? or after the big crunch?" (Steinhardt 2002).

Another alternative explanation is cosmic natural selection and the self-organisation of the cosmos: Lee Smolin assumes that the evolution of the cosmos is based on mechanisms that are analogous to the self-organisation of complex systems. The basic idea is that natural selection works at the cosmic level and produces new universes. Universes would originate from black holes. When stars die they sometimes form black holes. Smolin assumes that inside a black hole it's possible for a small region to, as it were, sprout into a new universe and that the laws of nature of a new universe are related to the laws that applied to the old

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universe from which the new one stems from. Space-time, Smolin assumes, doesn't end in black holes, it rather expands to new regions. According to him, universes whose laws permit the formation of black holes will tend to leave more "progeny" than those with different laws, and hence there will be an increasing chance that any given universe will contain black holes. We thus get a process of natural selection, whereby universes that favour the production of black holes will tend to outnumber other universes. This means that a new universe is produced by a universe or a network of universes that has a high production rate of black holes.

Smolin opposes the creation myth and considers an infinite existence of time, space and matter. "If the quantum theory of cosmology requires a non-constructible procedure to define its formal setting, it is something that could only be of use to a mythical creature of infinite capability. One of the things we would like to demand of a quantum theory of cosmology is that it not make any reference to anything at all that might be posited or imagined to exist outside the closed system which is the universe itself" (Kauffman/Smolin 1997). "There never was a God, no pilot who made the world by imposing order on chaos and who remains outside, watching and proscribing. ... The world will always be here, and it will always be different, more varied, more interesting, more alive, but still always the world in all its complexity and incompleteness. There is nothing behind it, no absolute or platonic world to transcend to. All there is of Nature is what is around us. All there is of Being is relations among real, sensible things. All we have of natural law is a world that has made itself" (Smolin 2002: 357f).

The weak anthropic principle (Robert H. Dicke) suggests that due to the fact that there are observers in the universe, the universe must have qualities that allow the existence of these observers. In its strong version (Brandon Carter) the principle suggests that the universe must be built in such a way that it necessarily results in the emergence of observers. This suggests finality. The anthropic principle is based on the assumption that if the parameters of the universe were only changed a little bit, life wouldn't be possible. Hence it is assumed that human existence is not based on chance, but that some type of necessity, mechanism of "finetuning" or teleology must be built into the universe. Such assumptions allow mystical and idealistic interpretations. If the universe inevitably produces the human being, then the inferences that there is a creator of the universe and that spirit is the highest form of existence (because spirit is assumed to be the absolute goal of the universe) is obvious.

"For example, it appears that electromagnetism, gravity, and the two main forces which control the atomic nucleus, had all of them to have strengths which fell inside very narrow limits if there were to be any stars of the long-living, steadily

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burning sort: the sort which encourage life to evolve. Again, life's complex chemistry appears possible only thanks to very precise adjustment of the masses of the neutron, the proton and the electron". (John Leslie, *Cosmology and Philosophy*, Stanford Encyclopedia of Philosophy)

Margaret Wertheim, host of the PBS TV programme 'Faith and Reason' argues: "The strong anthropic principle suggests that the laws of the universe are fine-tuned and have been designed to enable beings like us to arrive. In some sense we become the purpose, the end-point, of the universe. To me, that's a re-importation of natural theology into science, the view that God designed the universe specifically to get man" (*God, Physics, and Turtle Soup*, In: *Science & Spirit*, July/August 2002)

Paul Davies: "A clear inspection shows that the Earth is endowed with still more amazing 'conveniences'. Without the layer of ozone above the atmosphere, deadly ultraviolet radiation from the sun would destroy us, and in the absence of a magnetic field, cosmic subatomic particles would deluge the Earth's surface. Considering that the Universe is full of violence and cataclysms, our own little corner of the cosmos enjoys a benign tranquility. To those who believe that God made the world for mankind, it must seem that all these conditions are in no way a random or haphazard arrangement of circumstances, but reflect a carefully prepared environment in which humans can live comfortably, a pre-ordained ecosystem into which life slots naturally and inevitably – a tailor-made world" (Davies 1980: 143). Davies says that there must be some great "cosmic plan". Stephen Hawking says that if the hot big bang model (same temperature everywhere at the beginning of the universe) is right, it "would be very difficult to explain why the Universe should have begun in just this way, except as the act of a God who intended to create beings like us" (Hawking 1988: 127).

The anthropic principle puts forward the Creationist myth, it doesn't consider cosmos, matter, space and time as infinite, but wants to limit the questions that science is allowed to ask. Hence explanations external to matter and along with it mysticism and esotericism enter. Alternative explanations seem to be much more reasonable than referring to the existence of God:

It could indeed be accident

It could be the case that the seeming arbitrariness of these values is an illusion and they are really necessitated by the deepest laws of physics, but attempts to find such laws have so far been unsuccessful.

Maybe a universe is only possible with such parameters

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Maybe what we consider universe is only part of a much larger universe or a multiverse or a sequence of universes and hence life is no accident, but can be explained by statistic probability

Lee Smolin assumes that cosmos evolves in a series of universes and that the natural laws of a new universe are a sublation of the natural laws of the universe where it stems from. Comparing a new universe with the one that generated it will show a slight difference in parameter values. If this is the case, the conditions that allow the existence of life have been generated by the self-organisation process of the cosmos. In cosmic natural selection, universes that produce many black holes are more probable. Any universe chosen at random will tend to be one that generates many black holes. Such universes are necessarily rather complex, and so are also good for life. A universe where black holes are abundant must have stars (to turn into black holes) and carbon (to help make stars). This means that any universe with different values of the fundamental constants has fewer black holes and is less likely to exist and survive. "Because the universe is itself a non-equilibrium system, it produces by its own self-organisation processes again and again the conditions that favour the evolution of life" (Smolin 2002: 191f). "I believe that the transition science is now undergoing is part of a necessary process of liberation from the influences of [an] essentially religious view of the world. What ties together general relativity, quantum theory, natural selection, and the new sciences of complex and self-organized systems is that in different ways they describe a world that is whole unto itself, without any need of an external intelligence to serve as its inventor, organizer, or external observer. These are all steps towards a more rational and more complete comprehension of the world based more on what we know and less on myths that have been passed down to us from past generations" (Smolin 2002: 232). Smolin stresses that the universe as we observe it is the result of a steady self-organisation and selection process that includes an increasing fine tuning over a long time.

Besides these alternative arguments it should be stressed that the proponents of the anthropic principle proceed from the false assumption of the finite character of matter, time and space whereas dialectical materialism conceives the cosmos in terms of the eternal, irreversible movement of matter in space-time. The assumption of a (single) universe finite in duration is essentially idealistic.

Philosophy deals with explanations of how single aspects of the world and single sciences are connected. It is the science of universality. Philosophy is the thinking study of material reality and the things that comprise reality. Philosophy works out notions and categories in order to describe and explain the total world process on a general level. Various idealistic, religious and esoteric theories explain the world

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as being created by God as an external first mover who is not moved himself. This violates fundamental philosophical theorems such as Occam's Razor: if the material world can be explained as its own reason as can be done by philosophically generalising theories of self-organisation, referring to an external creator is an unnecessary over-specification and multiplication. The theorem of foundation holds that everything that is or can be has some foundation/ground. By starting to tell the history of the cosmos from physics, matter can be conceived as its own reason and as the self-referential foundation of the world. Philosophy actually must explain the development of the universe and must start from physics as the fundamental natural science, idealistic conceptions that stresses spirit will fail to find a sufficient ground of the universe (Zimmermann 1999)¹¹. If Spirit and God are conceived as eternal entities that are their own reason, irrational categories are simply defined tautologically and without reference to the really existing, material world that can be rationally explained by the natural and social sciences. Idealism can't provide a reasonable foundation of the world.

The existence of God has never been proved scientifically, but there is all reason to assume that matter is organising itself and that this is a universal phenomenon. The theory of the hypercycle by Manfred Eigen provides an explanation of the origin of life and the human being that is in no need for an argument that assumes divine creation because the emergence of life is explained as a qualitative leap in the self-organisation of matter that results in a new organisation level within an evolutionary hierarchy. Life is the result of a cross-catalysis between auto-creative nucleic acids and proteins. "There is no need for a miracle, for a divine, supernatural act to explain biological development. The only possibility of avoiding this conclusion would be the statement that the laws ruling it have been created together with the world by an extrahuman force. But then reasonable arguments for the possibility and necessity of this extranatural power must be found, and that cannot be established by scientific means" (Steigerwald 2000). The existence of life is due to self-reproducing molecules, there is no scientific evidence for a creation of life and the human being by God.

¹¹ Law of Ground: "Ground, like the other determinations of reflection, has been expressed in the form of a law: everything has its sufficient ground. This means in general nothing else but: what *is*, is not to be regarded as a merely *affirmative immediate* but as something *posited*; we must not stop at immediate determinate being or determinateness as such, but must go back from this into ground, in which reflection-into-self in contrast to mere being is expressed. To add that the ground must be *sufficient* is really quite superfluous for it is self-evident; that for which the ground is not sufficient would not have a ground, but everything is supposed to have a ground" (Hegel 1969: §969).

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Idealism is in one of its version based on a dualism of mind and matter, in another one matter is reduced to mind. Taking a look at the history of the division of labour shows that this division resulted in a widening separation between manual and mental labour. The emergence of this separation coincides with the emergence of class-based society. Idealism got a boost from the emergence of classes and heteronomous societies and the other way round it is an ideology that justifies and is helpful in upholding such societies¹².

With the breakdown of Fordist capitalism in the sixties, the capitalist world system entered a permanent crisis and ever since the global problems have quickly worsened. A new Postfordist mode of capitalist development emerged and individualisation has shown up as a new phenomenon that serves dominating interests and results in the erosion of collective institutions that formerly seemed to give sense to the human being. Such institutions are traditional religions, unions, associations, families etc. Capitalism is now based on a deregularised and flexible institutional setting (flexible regime of accumulation, neo-liberal mode of regulation) and people throughout the world are faced with the dangers of precariousness and extinction that are due to the development of the internal antagonisms of the capitalist world system. With the breakdown of the Soviet Union, an ideological vacancy showed up and the former Eastern European states have been fully included into the global capitalist dynamics.

In ideology and science, the emptiness and helplessness that is felt by many and that is due to the antagonisms of the capitalist world system has resulted in a search for new transcendental and mystical explanations and salvations. As a result there is a boom of various forms of mysticism, esotericism and spiritualism. People are looking for irrational guidelines, instead of looking for the foundations of problems and developments within the real world. The new irrationalism is a result of the increased complexity of the world that people can't cope with. These irrational tendencies can also be found within the self-organisation paradigm that has by some been interpreted as holistic spiritualism.

E.g. for the Austrian systems philosopher Erich Jantsch spirit is the guiding force of evolution, spirit's self-organisation would result in organisational levels. For him, history is history of the spirit and he says that the materialistic argument that humanity can be described by material processes is reductionistic (Jantsch 1979:

¹² "Essentially, philosophical idealism is a product of the extreme division between mental and manual labor which has existed from the dawn of written history down to the present day" (Woods/Grant 2002: 36).

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252, 330, 346). He considers the history of nature as the evolution of consciousness and spirit (1979: 411) and suggests that spirit is a god-like principle. God is considered as the evolving spirit of the universe.

Jantsch suggest that there is a hierarchy of natural systems (Jantsch 1975: 72) that stretches from physical to biological, social and finally spiritual systems. Very similar to the world model of Karl Popper (see Eccles/Popper 1977: 38) where world three corresponds to the products of human mind, spirit seems to be some upper guiding principle of evolution for Jantsch. Hence the upper system in his hierarchy is not society – that includes material processes as well as human ideas –, but spirit. This again outlines Jantsch's idealistic view of the world. Jantsch (1979: 243) says that it is the neural spirit that steers the evolution of the human world.

Jantsch (1975) refers positively to Henri Bergson's eschatological and metaphysical concept of *élan vital*, a life force that (as is assumed) drives evolution toward higher forms of organisation. Jantsch himself says that the formation of life should not be explained by random fluctuations, but by a special, attractive, higher force that drives towards finality and was called *entelechy* by Hans Driesch and *élan vital* by Bergson. Self-organisation theory puts forward the idea that life has come into existence by the self-organisation of matter without an external creator (God) or a metaphysical force at work. Although Jantsch is into this theory and tries to apply it to society, he is explaining life in an irrational manner. For Jantsch evolution does not take place randomly or as a dialectic of chance and necessity, he sees some finalistic, teleological principle at work. Jantsch's view is a monistic idealism, he says that all human systems – organisations, institutions, cultures, and so forth – are alive (Jantsch 1975: 50) and that self-organisation on all evolutionary levels means the unfolding of spirit (*Geist*). Jantsch's says that spirit is everywhere dissipative self-organisation takes place, especially in all areas of life (Jantsch 1979: 227). For Jantsch, spirit is also in society, eco-systems, the "gaia"-system or in the insect world.

Similar arguments can be found in the works of Fritjof Capra who considers the total dynamics of self-organisation in the cosmos as cosmic mind and regards self-organisation as a mental process. "In the stratified order of nature, individual human minds are embedded in the larger minds of social and ecological systems, and these are integrated into the planetary mental system - the mind of Gaia-which in turn must participate in some kind of universal or cosmic mind. The conceptual framework of the new systems approach is in no way restricted by associating this cosmic mind with the traditional idea of God. In the words of Jantsch, "God is not the creator, but the mind of the universe." In this view the deity is, of course,

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neither male or female, nor manifest in any personal form, but represents nothing less than the self-organizing dynamics of the entire cosmos“ (Capra 1982).

In such mystical views, the universe is seen as one large living totality that consists of a network of equal parts. There is no hierarchy in nature in such conceptions and hence also no qualitative differences between systems, they are all considered as an expression of spirit. Based on the Gaia hypothesis, biologicistic and eco-fascistic arguments frequently are employed.

In such new mystifications and irrationalifications of science, God is not necessarily considered as an eternal creator, but there is an eternal principle that exists externally to matter. Capra stresses the similarities between his systems view and mystics. Consciousness is regarded as the primary reality and the ground of all being. “In its purest form, consciousness, according to this view, is non-material, formless, and void of all content; it is often described as "pure consciousness", "ultimate reality", "suchness" and the like. This manifestation of pure consciousness is associated with the Divine in many spritual tradions. It is said to be the essence of the universe and to manifest itself in all things; all forms of matter and all living beings are seen as forms of divine consciousness“ (Capra 1982). Capra doesn't consider material structures as primary reality, all structures of the universe from particles to galaxies and from bacteria to human being are considered as manifestations of the cosmic mind. “But this is almost the mystical view“ (Capra 1982). Capra says that both the ideas of the universal interconnectedness and interdependence of all phenomena and the intrinsically dynamic nature of reality can be found in science and mystical traditions.

Philosophy is not an area of religious belief, religion is not a part of science and philosophy. Values and norms are part of ethics, which comprises one part of philosophy. The other ones are ontology (What is the world and all being like?) and epistemology (How do we perceive the world?). Philosophy is not an area where “anything goes“ in the sense of a radical constructivist or anarchistic epistemology of science as e.g. put forward by Paul Feyerabend. Philosophy instead tries to connect, to generalise and to unify single sciences. It produces interrelationships between single sciences on a more general meta-level. Hence it is based on the natural and social sciences, philosophical categories are related to the single sciences. E.g. categories like reason, love, human being are related to the humanities, categories like nature, space, time, matter are related to physics etc.

Categories like God and spirit that are conceived as the Absolute, as something infinite and unquestionable and as absolute truth are not at all connected to the single sciences. This results in isolated doctrines that can't be analysed, questioned

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and examined scientifically. There is e.g. no proof for the claim that man occupies some lower steps in a universal field where God means the Absolute. The realm of religion, mysticism, spiritualism and esotericism is where science ends and pure ideology starts.

Hegel said that “what is reasonable is actual and what is actual is reasonable“. Actuality means materiality, hence putting Hegel from head to toe means that only material reality can be reasonable, and that something that is conceived as existing prior or external to matter is unreasonable. Areas such as religion and esotericism are unscientific and irrational, they proclaim absolute truths that can't be researched or contested. Irrational arguments avoid objectiveness, exactness, logic, verifiability and falsifiability. Pseudo-sciences use strategies of immunisation in order to avoid criticism. If pseudo-sciences like creationism, spiritualism, mysticism, parapsychology and astrology were right, this would mean that the modern sciences are all wrong. Hence isolationism is typical for such areas of thinking.

There are no scientific grounds for religion and other irrationalisms. Religions might include some elements that are interesting for science and philosophy, but one has to deal with these topics scientifically, not religiously and in terms of absolute truths. Religion and esoterics are a “universal basis of consolation and justification. Religious suffering is, at one and the same time, the expression of real suffering and a protest against real suffering. Religion is the sigh of the oppressed creature, the heart of a heartless world, and the soul of soulless conditions. It is the opium of the people“ (Marx 1844b: 378).

There is no need to refer to mystic forces for explaining the self-organisation of the universe and society. New properties simply emerge due to the complex interactions of the parts of a system, not because there would be some external holistic force at play. Already the founders of the Philosophy of Emergentism, Conwy Lord Morgan and Samuel Alexander saw emergence as something mystically, and so they introduced spiritual forces (known as "Nisus") as the driving principle. Such forces lack an understanding of the dialectical relationship of quality and quantity and the whole and its parts. The emergence of order doesn't need to be explained metaphysically because new qualities of the whole are solely constituted by interactions of its parts. The philosophical mistake of over-specification that is grasped by Occam's razor is made by holistic thinkers such as Jantsch and Capra. This opens the way for irrationalism and esotericism, which belong to the scope of ideology rather than to (critical) science.

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