Scott H.

# SCIENCE AND NATURE

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## SCIENCE AND NATURE

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## EDITORIAL CORRESPONDENCE

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*Contributions of all types welcome.* An editorial advisory committee is now being formed.


*Initiators: Hyman R. Cohen, Lloyd Motz, Lester Talkington.*

*Ideology in Science and Vice Versa* ————————————

In general, bourgeois ideology not only penetrates science by imposing preconceptions on it but is also itself penetrated by science, at the same time often seeking to "interpret" and explain away scientific discoveries.

But above all, science plays a part as a weapon of criticism in the development of ideology. New concepts and discoveries of science conflict with existing ideology, and shake its preconceptions and the conclusions derived from them. So when new classes are rising to challenge the sway of the old ruling classes, and new ideas are being opposed to the old ideas, scientific investigation and the conclusions derived from it become a revolutionary weapon of criticism.

— *Maurice Cornforth, The Theory of Knowledge, International, 1963.*



## LETTERS TO THE EDITOR

### *On Dogmatism versus Dialectics*

The notion that space and time are infinite was propounded by Engels (pp 24, 202) and Lenin (p 267). This notion was explicated in *Fundamentals of Marxist-Leninist Philosophy* (p 86) as follows:

> As real forms of the existence of matter, space and time are objective, [existing] outside of and independently of consciousness ... eternal, inasmuch as matter exists eternally ... boundless and infinite [because] ... no matter in what direction we move or how far we go from our starting point, there will never be any boundary beyond which we can go no further ... No matter how enormous any given cosmic system (for example, our Galaxy), it forms part of an even larger system ... The infinity of space is the infinity of the volume of the whole countless totality of material bodies in space.

Referring to the above statement, Irving Adler (*Science and Nature* 1:9, 1978) contends that "the assertion on purely philosophical grounds that 'space and time are boundless and infinite' " constitutes "dogmatism" in which the principles of dialectical materialism are used "as a set of rules that nature *must* obey" [emphasis in original]. He counters with the assertion: "In relativistic cosmology, the answer to the question 'Is space finite or infinite?' will be obtained only by measuring relevant parameters and not by making some arbitrary presupposition."

Adler thus takes the position that determination of a closed, finite space is subject to observational proof on a solid scientific basis while the assertion of infinity for space (time and matter?) derives purely from an arbitrary *a priori* philosophical tenet. In reality, the situation is not that one-sided; each of his assumptions suffers grave weaknesses.

Relativistic cosmology offers many models of the Universe, including that of a closed, finite space, but not one of these models has been empirically established (d'Abro pp 300 ff, Burbridge pp 170 ff) and none excludes the possibility of an empirical determination that space is infinite.

As yet there is *no* empirical evidence that clearly contradicts the notion of an infinite Universe. In fact, some observations of the very distant galaxies and the quasars lead to interpretations that conflict with the Hubble Law (Mitton p 376). The Hubble Law provides the basis for the Big Bang theory that postulates a Universe with a finite mass which, in turn, provides the basis for models with finite space. There is even evidence that the question of finiteness of space is inherently not subject to empiric decision (Motz p 176, Field p 145).

On the other hand, as the technological tools for observation have improved and the observational studies have multiplied, the observed quantity of matter and the space it occupies have consistently increased. Similarly, since Engels and Lenin wrote on the question, we have come to know even greater diversity in the forms of cosmic matter and their transformations. Hence, one can say that the empirical evidence continues to grow in support of the materialist philosophical position for an infinite Universe, as opposed to a finite space (with a demarcation between that space and what?).

Since the question has not been settled empirically and may never be, there is a necessary role for philosophy in helping to generate or select the most useful hypothesis to guide further studies. It seems that a Marxist would prefer a hypothesis that is both consonant with dialectical materialism and in accord with available empirical evidence, especially when the alternative is an "empty" statement that offers only skepticism concerning our knowledge of the material Universe except as it may be determined by dubious or uncertain observations at some indefinite future time. To deny philosophy a positive role in such a situation is to hobble science and provide the basis for converting some particular theoretical model into dogma.

*Hyman R. Cohen, Brooklyn, NY*

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## Why Do We Have Non-Believers

Why is it that some people, who accept the validity of historical materialism and believe in socialism, still refuse to believe that dialectics apply to the motion of inorganic matter? Here is an explanation that I find helpful:

Karl Marx said that in order to understand the socio-economic formations which preceded capitalism, it was first necessary to study the latter, more advanced form of society. It seems to me that the situation with respoect to the philosophical question is analogous. There are three broad types of evolution: 1) the physio-chemical (inorganic matter); 2) the biological; and 3) the social. Yet when it comes to ease of understanding the application of dialectics to the processes of change, we would have to rank these in reverse order. The social is the more advanced and it has the higher rate of change which makes its dialectics easier to grasp. The most primitive form of evolution and the most difficult to grasp as dialectical is that of physio-chemical matter.

I hope that others also find this explanation helpful.

*Saul Birnbaum, Bronx (NY) Community College*



## The Dialectics of Catastrophe Theory: PRO and CON

I was very pleased by the first issue of *Science and Nature,* particularly the article by Martin Zwick on catastrophe theory and dialectics. Last summer I wrote for my file the following research note suggesting an interpretation of catastrophe theory in terms of dialectical principles.

Roughly, catastrophe theory describes the nature of possible stable states of any system. The transition from one stable state to another is called a "catastrophe". Catastrophe theory provides mathematical descriptions of such transitions.

It is suggested here that catastrophe theoretic descriptions of transitions in non-equilibrium systems can be interpreted in terms of Marxist dialectics. According to the laws of dialectics, all systems are in a continuous process of development. When considered from a dialectical point of view, the development of systems is determined by the balance of opposing or contradictory tendencies within the system in question. The state of overall development, or quality of a system is determined by the relative strengths of these opposing tendencies. The relative strengths of these tendencies can be conceived as quantities - i.e. one tendency may be conceived as greater or stronger than another. When one tendency comes to predominate in such a way that its opposing tendencies are completely transformed or dissipated, the system in question may lose its integrity, or begin to develop in a new direction. Further development will also be characterized by the interplay of opposing tendencies.

When catastrophe theory is interpreted in terms of dialectics, the opposing tendencies in a system represent the forces holding the system in a particular stable state, in opposition to those impelling the system to a "catastrophe point" where the system will achieve another stable state, or disintegrate. If disintegration occurs, the components of the defunct system become parts of another system or systems whose development is also dialectical.

The foregoing application of dialectical principles differs from several contemporary interpretations of dialectics as (1) a developing relationship between "subject and object", (2) "praxis", or, (3) the development of scientific thought a la Kuhn. Rather, the application of dialectics proposed here is similar to those advanced by scientists such as Haldane and Bernal in the 30s. It implies the existence of "dialectics in nature," as suggested by Engels. This interpretation is rejected by the "Praxis School," the "Telos Group," and other current philosophical schools of Marxism.

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*Dennis Bartels, Dept. of Anthropology*
*Memorial University, Regional College*
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*A2H 6P9*

For the other side of the controversy see Lantzy, Dacey, Mackenzie, Borchardt and Platt: "Catastrophe theory: Application to the Permian mass extinction." [*Geology* 5:724-728, 1977 and 6:453-454, 1978].

In my opinion, catastrophe theory is a good representative of the bourgeois idea of "the universal disconnection," which is anti-dialectical to say the least! Apparently the theory is based primarily on mathematical imagination. In the real world, the discontinuities are as rare as perfect vacuums and hen's teeth.

Enjoyed first issue of *Science and Nature.* Keep up the good work.

*Glenn Borchardt*
*California Division of Mines & Geology*
*San Francisco, Calif. 94111*

*Editorial Addendum.* The detailed interrelationship of bifurcation theory and catastrophe theory is discussed by J.M.Y. Thompson in *Bifurcation Theory and Applications in Scientific Disciplines,* edited by Okan Gurel and Otto E. Rossler (Ann NY Acad Sci v 316, 1979). Emphasis is on application in exact sciences. The conceptual history of bifurcation theory is traced by Gurel back to Euler, Poincare, Liapunov and Andronov.

### *Pipedreams and Benchwork Science*

Enclosed is a check for my subscription. Glad to see somebody is actually pursuing in the concrete an activity about which I have often pipedreamed. I have a research interest in how a mode of production affects the conceptual development of science. And, over the years, I have tried to flesh out the implications of a dialectics of nature for benchwork science—in particular, the alternative doors it may open for microphysics. Looking forward to meeting your group.

*Paul Raskin, Cambridge, Mass.* □



*Dialectics Workshop*
*Harvard University*
*18 November 1978*

*Invited Paper (an excerpt)*

**STEPHEN JAY GOULD**
**Comparative Zoology**
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## The Episodic Nature of Change Versus the Dogma of Gradualism

How do biological forms arise? According to evolutionary theory, there are only two possibilities. In one model new species arise by the transformation of one population into another, whether gradually or not. This process is labeled anagenesis or phyletic evolution. In the other model, new species arise by a process of splitting that's called cladogenesis or speciation. The terminology is unfortunate because obviously phyletic evolution also produces new species. When a population gets to look different enough you give it a new name. But, technically, only the process of splitting is called speciation.

The conventional view among geologists today is that the process of anagenesis yields "progress" in evolution whereas speciation is, in a sense, derivative; all it yields is more diversity, variations on a theme. For example, Francisco Ayala says: "Anagenesis or phyletic evolution consists of changes occurring within a given phyletic lineage as time proceeds. The stupendous changes from a primitive form of life some three billion years ago to man or some other modern form of life are anagenetic evolution. Cladogenesis occurs when a phylogenetic lineage splits in two or more independently evolving lineages. The great diversity of the living world is the result of speciation." [*Molecular Evolution* 1975]

Against this standard viewpoint, I would like to argue that anagenesis is unimportant in evolution and probably doesn't happen very often. Large, successful, stable, central populations will of course adapt locally and undergo slight fluctuations. A classic example is the English moth *Biston betularia:* a whole geographic population turned black as an adaptive response to darkening of trees after the industrial revolution. But this did not create a new species since the black gene already existed and all that happened was an increase of its frequency in the population. Minor adaptive shifts such as this happen all the time. But I think the actual production of new species almost always occurs in the splitting mode of speciation. That, of course, doesn't guarantee anti-gradualism since speciation might occur as a slow and steady departure, so that the splitting might be just another case of gradualism.

My claim that most evolution occurs in events of speciation, and that this result supports anti-gradualism, depends upon the nature of speciation. I'd like to defend the notion that speciation is a process that occurs on a time scale of hundreds or thousands of years (a mere geological instant, though it might seem slow to a human observer) and that speciation usually occurs in small isolated populations cut off from genetic contact with the parental form. In this view, the geological record for, say, 2,000 years is not a hillslope up which you can trace gradual change but a bedding plane or stratum that won't be seen at all.

I like to call this the model of punctuated equilibrium. In the normal time course of a species in equilibrium, not very much change is to be expected. Evolution is not the intrinsic flux of the universe, proceeding at a gradual rate all the time. For most of the time with most species nothing but minor adaptive fluctuation occurs. But this equilibrium is punctuated now and again by events of speciation which, in geological perspective, are essentially instantaneous. That's the basis of my model.

The standard representation for gradualism is shown in *Figure 1.* But an abstract tree of life is not a neutral hat rack for the facts of paleontology. It is a model that shapes one's view of the process, what I call the view of stately unfolding. Life just gradually diversifies on the tree. You don't see any signs of abrupt periods of adaptive radiation or of mass extinction. *Figure 2*, on the other hand, is an attempt to portray my view of punctuated equilibrium, showing what I think evolution is more like in geological perspective. Granting the homeostatic tendencies of a species, when there's change it's abrupt in the origin of species. You can get trends this way, but trends under the notion of punctuated equilibrium are produced not by the transformation of a central population but by a higher phenomenon, a sorting out of species, a differential success of one kind of species versus another kind of species. In this way, speciation itself becomes the input to theories of macroevolution, not simple changes of gene frequency in populations. *[Figures on page 12.]*

Now I will raise a more general question: Why were Lyell and Darwin such convinced gradualists if, in fact, they didn't see it in the rocks (though most geologists probably think they did)? I think there are a lot of reasons. I think it's pretty undeniable that one important source of gradualism, if not *the* most important, really has to do with political ideology, at least covertly. It's not terribly radical to say that virtually any society has to construct an ideology implying that the preservation of its mode of life coincides with rightness in the universe. An example is the idea of all planets moving around the earth like bishops around the pope and peasants around the lord. Galileo wasn't shown the instruments of torture just because he had some funny idea about what circulates around what and, though Brecht's play *Galileo* isn't historically accurate, it captures correctly the



theme that the church had a lot more at stake than a revised cosmology. But when this static world order collapsed in the eighteenth century, it became necessary to acknowledge that change was an intrinsic part of the universe; an ideology had to be constructed around notions of change. The question arose: What kind of change? The answer, we see, is that although change is intrinsic, it is slow, steady, gradual, and weighted down by the vestiges of the past. It wasn't necessary for Queen Victoria to get on a non-existent telephone and say to Charles Darwin: "Construct me a theory of gradualism in paleontology because the natives are restless." People understand, at least unconsciously, how to record their interests.

I have a couple of anecdotes that illustrate the utility of gradualism as an explicit defense against rapid or revolutionary change. The first is from a marginal character whose name, General Augustus Lane Fox Pitt-Rivers, shows that he was not a member of the working classes. He was an anthropologist who set up a museum in Dorset in the 1890s. In its prospectus he wrote:

> For good or evil we have thought proper to place power in the hands of the masses. The masses are ignorant and knowledge is swamped by ignorance. The knowledge they lack is the knowledge of history. This lays them open to the designs of the demagogues and agitators who strive to make them break with the past and seek remedies for existing evils in drastic changes that have not the sanction of experience. It is by knowledge of history only that such experience can be supplied. The law that nature makes no jumps can be taught by the history of mechanical contrivances in such a way as at least to make men cautious how they listen to scatterbrained revolutionary suggestions.

The second quote, rather more poignant from our point of view, is from Booker T. Washington and I think it illustrates why he was the darling of whites in his own day and is not tremendously beloved of most Blacks today. In his book *Working with the Hands* (1904) he says:

> Finally, reduced to its last analysis, there are but two questions that constitute the problem of this country so far as the black and white races are concerned. The answer to one rests with my people. For my race, one of its dangers is that it may grow impatient and feel that it can get on its feet by artificial and superficial effort rather than by the slow but sure process which means one step at a time through all the constructive grades of industrial, mental, moral and social development which all races have to follow to become independent and strong.

Now gradualism isn't the only intelligible philosophy of change; it's just one that our society nurtures covertly or unconsciously. In the European tradition there are other philosophies of change. There are dialectical laws, particularly the law of transformation of quantity into quality. The dialectical laws represent a different approach to scientific analysis. When such alternate philosophies of change are adopted in other nations, it is easy for us to identify the ideological component. When the Soviet handbook on Marxism-Leninism explains the law of transformation of quantity into quality by means of examples—when you heat up water it boils at a certain point; when you bend a beam it will break at some point; and, if you oppress the workers more and more, eventually this leads to revolution—we have no trouble identifying the ideological component in this notion of change. I would make a plea for people to see the ideological component in our preference for gradualism as well.

Some of the early Marxists did indeed pick up on the ideological character of a belief in gradualism. For example, Plekhanov wrote in 1903:

> Then the people confuse dialectics with the doctrine of development. Dialectics is in fact such a doctrine. However, it differs substantially from the vulgar theory of [Spencerian] evolution which is based on the principle that neither nature nor history proceeds in leaps and that all changes in the world take place by degrees. Hegel has already shown that, understood in such a way, the doctrine of development is unsound and ridiculous.

Karl Kautsky *(Social Revolution* 1902) is even more interesting in his political interpretation of why the doctrine of gradualism became the order of the day in the 19th century.

> [The once progressive bourgeoisie] must seek more powerful arguments to stigmatize the revolution and these are found in the newly rising natural science with its accompanying mental attitude. While the bourgeoisie was still revolutionary, the catastrophe theory still rules in natural science [I'm not sure this is a valid equation. SJG]. This theory proceeded on the premise that natural development came through great sudden leaps. Once the capitalist revolution was ended, the place of the catastrophe theory was taken by the hypothesis of a gradual imperceptible development proceeding by the accumulation of the capitalists' little advances and adjustments in competitive struggle.

Kautsky then makes an interesting point about social utility:

> The issue isn't really external truth in nature. The fact that an idea emanates from any particular class or accords with their interest, of course, proves nothing of its truth or falsity. But its historical influence does depend upon just these things. To be sure, our conception of the one will unconsciously influence our conception of the other sphere, as we have already seen (i.e., nature and politics). This, however, is no advantage and it is better to restrain than to favor this transference of laws from one sphere to another.

That's an interesting insight: one ought not to make easy transfers from nature into human culture because one isn't seeing nature as truth and culture as bias, anyway. Kautsky's main point, however, is that, although historical utility is an important determinant, the question of whether gradualism is, in fact, a good or bad way of looking at the world depends on more than social utility. Quite apart from recognizing that gradualism may have its roots in cultural and political bias, there are good empirical reasons for looking at other models of change. Today I see work in field after field that advocates punctuational models of change. It comes in part out of our more contentious times. People are seeing justification for punc-



tuational change all over. They are understanding that gradualism has been a restraining dogma.

Take this curious article from, of all places, *Forbes Magazine*, in which David Warsh states: "Now prepare for a bit of a shock. Karl Marx was more right than Adam Smith." The author then defends various styles of punctuational change, identifying Smithian and particularly Keynesian economics as notions of pervasive gradualism:

> The idea of catastrophic development has become quite familiar — of a system sitting quietly in equilibrium while its underlying forces are slowly changing until a point is suddenly reached where equilibrium breaks down and the system snaps to a new equilibrium. Catastrophies so defined are common in nature. Liquids boiling, beams buckling, shock waves forming, rainbows appearing, oscillators shifting phase, boats toppling over, stars exploding, quantum physics, Mendelian genetics, René Thom's catastrophe math, all depend on the existence of discontinuity.

That's perhaps too long a list but it's not a bad description of the law of transformation of quantity into quality.

In fact, though I have argued for punctuational evolution on a geological time scale, there are now theories of punctuational evolution even in ecological time, i.e., within our lifetimes. H. Carson working on *Drosophila* and Michael White on Australian grasshoppers claim that major chromosomal alterations producing reproductive isolation can bring about the origin of new species in ecological time. And Princeton ecologist Robert May is trying to produce a mathematics of discontinuous change reflecting thresholds and breakpoints in ecosystems with a multiplicity of stable states. In *Nature* 6 Oct 1977 he says:

> Thus smooth changes in stocking rates can cause discontinuous changes in grazed vegetation, continuous changes in harvesting rates can cause discontinuous collapse in fisheries. Continuous changes in environmental parameters (foliage growth, predation rates) can lead to discontinuous outbreaks of insect pests. Continuous changes in snail or diptera population density can cause discontinuous appearance or disappearance of helminthic [parasitic worm] infections.

Again we see the transformation of quantity into quality in our own ecological framework.

I think the fascination in so many fields for René Thom's catastrophe theory reflects a desire many people feel for a mathematics of discontinuous change. Whether or not you think it's good mathematics (I'm neutral on this, not being enough of a mathematician to analyze it) and whether you like most of its applications (I think a lot of them are nonsensical), the very publicity it receives shows the good feeling a lot of people have for the idea.

To summarize, I see notions of gradualism arising largely out of pervasive political bias, particularly in the 19th century, and today a pretty general collapse of the notion that change, to be intelligible, must be gradual. (I don't say that there are no gradual changes in the universe.) I also see the replacing of gradualism with the flip-like style of change which has been appreciated within Marxist philosophy for a long time. I see this not as a dogma but as an alternate or pluralistic widening of the ways we look at change. This development may be part of a general intellectual movement of our times.

*AUDIENCE INTERACTION*

**Unidentified (1).** It seems to me that in attacking the dogma of gradualism you have tackled two logically distinct things. One is the idea of a constant rate of change, on which you did splendidly. The second is the doctrine of having to go through all the intermediate steps, on which you leave room for the opponent to argue that the rate of change may not be constant but nonetheless the duration of a geological instant leaves time enough for evolution to proceed through all the intermediate steps.

**Gould.** I agree with you that there are two separate points. I'm talking here mostly about rate of change. But, in classical paleontological gradualism, the first main theory was that by tracing evolution up the hillslope one would find all the intermediate steps. Some paleontologists still think that way, but I don't believe that all intermediate stages could be found in all situations. In my book *Ontogeny and Philogeny* (1977) I argue that small genetic changes, if they translate themselves early in ontogeny, can have major discontinuous effects in adult phenotypes. In fact, the notion of genetic continuity does not necessarily translate into phenotypic continuity, which seems to answer the second argument.

**Unidentified (2).** When you knock down gradualism, don't you also knock down the random selection aspects of evolution?

**Gould.** No, random selection is primarily a notion that variation does not come packaged in the right direction, not packaged differentially in the direction of adaptation. The abstract notion of Lamarckianism is that the activity of organisms brings about variation in the right direction. This leaves no room for a creative role of natural selection since the fittest arise differentially anyway. In fact, even if you have random deaths, if the fit arise differentially, you will eventually get directed change. The notion of random variation doesn't basically refer to the size of the change, only to the direction of the variation around the mean. Though Darwin himself saw only small changes as important, you can have Darwinian selection operating in larger steps, provided that those steps don't occur packaged in the direction of adaptation differentially.

**David Schwartzman (Howard University).** You say that every scientist has to make the methodological assumption of constancy in natural law because the past is untestable, we can't see the past. But what is the nature of seeing? You see the past when you look into the sky with a telescope, what galaxies looked like eons ago, and you can test the constancy of gravitational theory with different cosmologies. In terms of radioactive methods, you can test whether decay constants are really constant. In that sense, I don't think the case for the necessity to assume constancy is as strong as you put it.

**Gould.** You can manipulate the present but not the past; you can't perturb the past or experiment with it. You can only test decay constants where you have independent chronology; testing carbon 14 against dendrochronology takes you back only 3,000 years. The only test for the constancy of uranium decay, as I understand it, is against potassium argon decay, not an intrinsic test. It's true that some of our perceptions are of things that happened long ago. C.S. Pierce argued that induction is self-corrective because you can produce the experiment again and again to see if you always get the same result. When I see scratches on a rock, I say they were caused by glaciers because I see that modern glaciers make the same kind of scratches. But, unless I am willing to say that the laws of nature are constant, I can't say that the ancient scratches were made in the same way because, in principle, I can't observe them in the past.

**Richard Levin (Harvard).** This comment is on a basic contradiction in the whole scientific enterprise. We study the unknown by making believe that it's just like the known. When we find, for example, pollen of cold climate plants with bones of hot-climate elephants, we have to say that either elephants then were not like elephants now or that the plants then were not like the plants now. When we find that the assumption of uniformity breaks down, we get the interesting insights. Some scientists absolutize the idea of uniformity and lose a lot by it. The problem of the origin of life was completely intractable so long as the world was visualized to be just like our world now except with no living things in it. As soon as it was recognized that the world then was different from the world now—because of life—then it was possible to figure out a little about the origin. In each case, the idea of uniformity was contradicted in order to get new insight.

**Unidentified (3).** I like your analysis of political bias in gradualism but what about the bias in your own theory. Do we have to go through the same process again? A hundred years from now will somebody come up with a similar political analysis against the ideological content of your theory?

**Gould.** Sure, there's bias in my theory. I read to you Kautsky's statement to show that you have to analyze ideologies to see why people believe as they do when they do. But I share what I guess is the metaphysical belief of all scientists that there really is a reality out there.

**Jonathan King (MIT).** That's not metaphysics. That's historical materialism.

**Gould.** It's my metaphysical belief that there is a reality out there, although our tortuous path to it is always impacted by our politics and where we're at. It may be true that a lot of people are talking anti-gradualism right now because of our political climate. While it's not irrelevant that my daddy raised me a Marxist, I might well have come to these ideas from a different political philosophy; it's not a matter of determinism. But I think that the main reason for my paleontological ideas was not conscious Marxism. As a graduate student it bugged the hell out of me that stasis and sudden replacement were the facts of my profession and nobody denied them; yet, in the expectations of evolutionary theory, they told me I should see something else and I never saw it. I really do think that punctuational equilibrium is the correct description for stasis and sudden replacement in evolution. There may be politics behind that. But, as Kautsky says, it may also be right.

**Unidentified (4).** You seem to say that investigation of the world confirms the laws of dialectics. You don't start from dialectics but your observations show that dialectics give a view of the world that explains its motion and growth.

**Gould.** I'd put it a different way. For me, dialectics have been very useful, allowing me to expand my views away from certain dogmas. When I was a student I accepted all this dogma about gradualism, never really thought it through. Dialectical laws helped expand my views. Changes such as those described by the dialectical laws do occur in nature. They describe what's important in the universe. Hegel didn't invent them out of nowhere. But I don't dogmatize these laws. I think of them as insights, as guides to looking at nature rather than as doctrines about the way change necessarily occurs in nature. I think they describe a lot of change that we have systematically *not* seen otherwise because of biases that are unconscious.

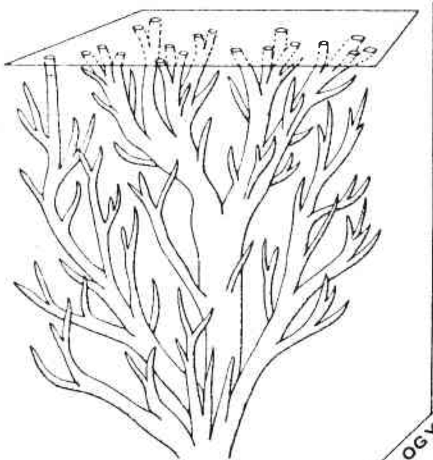

FIGURE 1

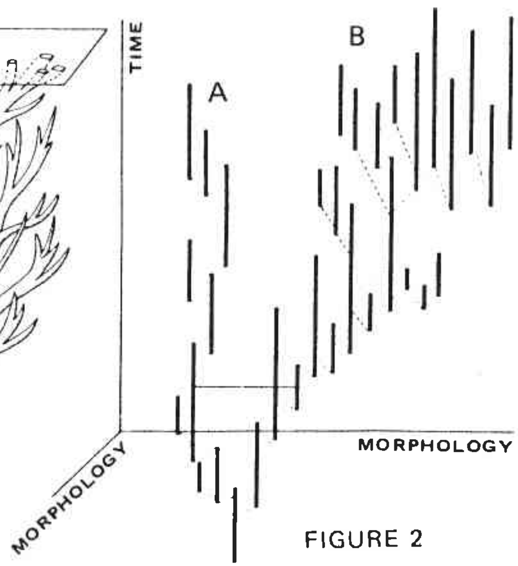


FIGURE 2

**FIGURE 1.** The "tree of life" viewed from the perspective of phyletic gradualism. Branches diverge gradually one from the other. A slow and relatively equal rate of evolution pervades the system.

**FIGURE 2.** Three dimensional sketch contrasting a pattern of relative stability (A) with a trend (B), where speciation (dashed lines) is occurring in both major lineages. Morphological change is depicted here along the horizontal axis, while the vertical axis is time. Though a retrospective pattern of directional selection might be fitted as a straight line in (B), the actual pattern is that of stasis within species, and a differential success of species exhibiting morphological change in one direction.



*Dialectics Workshop*
*Harvard University 18 November 1978*
*Contributed paper*

## THE POLITICAL ECONOMY OF CANCER RESEARCH

**David Ozonoff (public health)**
**Boston University School of Medicine**

Cancer is not the only disease intimately connected with modern industrial society but it is surely one of the most melancholy. For the last year and a half a group of researchers, all interested in cancer from a scientific or policy viewpoint, has met regularly to try to make sense out of the U.S. cancer problem. In my summary of the results there are no real surprises since they repeat a familiar pattern seen in many other areas of science. But they represent an attempt on the part of the working scientists to apply Marxist analysis to a professional problem for the purpose of finding a progressive solution.

Much of the overall effort went to filling in the overall picture and thus to understanding where the gaps existed. As the result of this study, it became very clear that the entire thrust of cancer research and the funding for it has been grossly mismatched with respect to what is known about the origins of human cancer. While large amounts of money and effort are expended on basic research into cell biology, especially the biology of tumor viruses, and even more goes into the development of new chemotherapeutic agents, very little goes into identifying the actual *causes* of cancer, the specific carcinogenic chemical and physical agents in our community, home and workplace environments.

Yet, at present, the only *effective* protection against cancer is the prevention of exposure to carcinogenic agents. It is estimated that there are upwards of 70,000 chemicals currently in industrial use, and about 700 new ones are added each year. Just which of these chemical agents can cause cancer is impossible to say without actual bioassay in some appropriate biological system. Carcinogenicity is not a property of a chemical *per se* but of a chemical and a particular organism in combination. Contrary to popular belief, most chemicals are not carcinogens. But, if only a small percent of the current roster of chemicals have cancer-causing potential, we have a major health problem on our hands.

Had we identified 70,000 different types of bacteria in our food and water supply, only a thousand of which were capable of causing human disease, one could be sure that a significant effort would be made to identify which organisms were harmful and to develop some way of eliminating them. In the analogous case of chemicals, however, we find that in FY76 the National Cancer Institute, the nation's chief cancer research organization and funding source, budgeted only just over 1% of its funds for carcinogenic bioassays, i.e., for the only program to determine the *cause* of most cancers. This means that most chemical agents in our environment have never been tested for their cancer-causing potential, even where a high index of suspicion exists. It is obvious that many unidentified and unregulated carcinogens are part of our everyday lives, especially in the workplace, and that no substantial effort is being made to rectify this situation within the research and academic world. While the press ignores this failure to search for the unknown carcinogens, undue emphasis is given to one particular known carcinogen, cigarette smoke. This is not an accident, since it is part of a general ideological tendency to "blame the victims" by implying that we get the deaths we deserve as a result of our intemperate personal habits.

One must ask the 'how' and the 'why' of this situation. Here it is not necessary to belabor the question of 'why'. Priority of research funding results in a systematic deflection of attention away from the true locus of any rational public health strategy, that locus being to stop the cause of cancer at its source. Instead, research focuses on either curative strategies or the basic cellular biology of tumor initiation. Focusing on curative strategies is like concentrating one's energy on better resuscitative measures for an epidemic of drowning victims without asking the question of who threw them in the water. Focusing on basic cellular biology is to substitute mechanism for cause, and thus abstract the problem from its economic and political context in order to empty it of all meaningful social implications. Clearly, in a class society such as ours, ideas and activities that threaten to expose basic conditions of exploitation, recklessness and disregard for the public health and welfare on the part of a small but powerful segment of our society, will tend to be suppressed, displaced or even inverted. Moreover, cleaning up the environment and the workplace will be expensive, and where profit margins are involved, other matters must take second place.

Following the dictum that the ideas of the ruling class tend to become *the* ideas of a class society, it is not surprising that "harmless" formulations of the cancer problem will tend to become widely believed and held by the most diverse members of society. But the *'how'* of this ideological process is less straightforward. I am reminded of a passage in the *Autobiography of Lincoln Steffens,* where Steffens asks an investment banker how the closing of saloons could hurt Wall Street which was then opposing a cleanup of the liquor trade. The banker kicked Steffens' shin hard which brought a yell, then asked "Why does your mouth cry out when only your shin is hurt?" Steffens found this answer helpful. "It was a picture I needed," he wrote, "a diagram of the connection between the saloon business and the banks, just as I had one of the nervous system that linked up my lower and upper extremeties." But Steffens, of course, was not satisfied until he got more details.

Though I cannot provide here a detailed diagram of how cancer research has been so alienated from social needs, I can perhaps give a sketch of why it is that many researchers, even liberal and left-leaning ones, cooperate so willingly and eagerly in a reactionary application of their scientific skills. The first element in the analysis is a recognition that all ideas, theories and concepts in science have a material social basis. Let me list some of the material factors that tend to favor alternative formulations of the cancer problem: there are faculty appointments, laboratory facilities and equipment that provide for certain types of experiements, publication of certain ideas in recognized journals, funding of certain lines of research, the nonexistence of sources of data that would answer certain types of questions, denial of access to other existing kinds of data (e.g., company health records) that would allow certain other questions to be answered, and so forth. We have the most detailed information about business and commerce. The government can tell me how many people commute between Westchester and Oswego County in New York but they can't tell me with certainty how many people have cancer in Oswego, despite the fact that New York State has a cancer registry (it has not been well supported).

Once you recognize that ideas are material social entities, not floating up there in some intellectual heaven, then you can begin to ask about the kind of environment in which these social entities live and what kind of hostilities they have to face. It's risky to use organic analogies ... so I'm going to do it. One can think of an idea almost as one thinks of a living organism. It has to be continually nourished with the resources that permit it to grow and reproduce. In a hostile environment that denies it the material necessities, scientific ideas tend to languish and die. Practicing scientists know well that the direction of their work depends greatly on where the material resources are. Though the clever grantsperson is amply rewarded by academia, one must ask what the result is in terms of the social "ecology" of researchable ideas.

How can we describe the environment that determines why some ideas make it and others don't. Certainly one relevant approach for a Marxist scholar would be to look at the class composition of the controllers of resources in the institutions where cancer research is conducted: medical schools, hospitals and universities. Vincent Navarro has provided us with some useful data on this material factor in his paper "The Underdevelopment of Health of Working America: Causes, Consequences and Possible Solutions" (Amer. Jour. of Public Health 66, 538-547, 1976). His data confirm the conclusions of our group that certain formulations of the cancer problem are likely to have an easier time of it than others.

It is obvious that the suppression, displacement or inversion of scientific lines of work that have threatening consequences for American capitalism is a general process that must be looked into more closely than is possible here. Much of it occurs well outside the laboratory, at the political level of funding source or within the institutions training future researchers. Occasionally, however it is made quite explicit by leading members of the profession. For instance, in explaining why the search for basic mechanisms was a valid approach to preventing cancer, a noted researcher has stated: "Although the removal of the carcinogen from the environment is obviously the most effective way to conquer cancer, it may require such a rearrangement of the environment that society cannot or will not allow this to be done except slowly over decades. A knowledge of the steps in the carcinogen process will almost certainly lead to ways to interrupt the process *in the continuing presence of the carcinogen*" [emphasis added] (Emmanuel Farber. *Current Researches in Oncology* 1973).

In this context, "rearrangement of the environment" is another way to say interfering with the economic and social structure, while the "society" that objects is, of course, that small group of people known as the U.S. ruling class. This example shows the considerable extent to which a basic line of public health research can stand in potent contradiction to the institutions that control the nourishing resources of resources. Researchers who recognize this are better able to organize the struggle for sustaining progressive lines of research in their field. They can begin to forge the necessary links with like-minded colleagues in their own and other institutions, and especially with allies in the organized labor movement where the potential economic and political strength resides.

*Audience Interaction*

**Peter Catalano** (Sidney Farber Cancer Institute). Aside from the treatment by the media, didn't the public have good reason for taking a negative view of removing saccharin from the market place—in terms of absurd experiments, high dosage and things like that which didn't make much sense. I think that a lot of research is viewed the same way. Second point, I can't fully agree with what you say about the cigarette problem. The government hasn't spared any pains in tackling the cigarette industry. Short of totally taxing cigarettes or banning them altogether, they seem to have done about as much as is possible to apprise people of the dangers in advertising and so forth. The other point is that, even if there are a thousand chemicals in the environment, they are crucial chemicals required for basic manufacturing. You're not just talking about some greedy guy's profit margin; there's the problem of finding substitutes for vital products.

**Ozonoff.** On your first point, about the public becoming disenchanted by cases such as saccharin, the public didn't become disenchanted by itself. Organizations such as the Calory Control Council ran large ads talking about the 800 bottles of diet soda that people had to consume, and so on. So did the Diabetes Foundation. I could also tell you something about the American Cancer Society and the way it funds research. I'd love to give you my three and one half hour lecture on these large propaganda efforts. But the reasons for banning saccharin are very, very good. There is no demonstrable benefit in saccharin. What people believe in this case is not a function of the truth of the issue but of the expensive propaganda effort to discredit the scientific research. In fact, the banning was done so maladroitly by the Food and Drug Administration that one suspects an organized effort there to discredit the research. On your second point, cigarettes are a complicated issue but the U.S. has been subsidizing cigarette and tobacco production for a long time. It's not true that they've done everything they could to discourage cigarette smoking. In Scandinavia they've doubled and tripled the taxes to make cigarettes very expensive. And there are many other things that could be done. But the U.S. government makes it very



easy for people to smoke cigarettes in this country and very easy for the tobacco companies to produce cigarettes profitably. Your third point was that many of these chemicals are important for modern life. How do you know that?

**Catalano.** You speak of testing 70,000 chemicals. You suggest a thousand are carcinogenic. Are you talking about sulphuric acid?

**Ozonoff.** First, I wasn't suggesting the removal of every carcinogenic chemical from the face of the earth. I was really suggesting that we make the biosphere safe for the human species ...

**Catalano.** Then you quoted this other fellow who said that we can identify these things but it's going to take time. I understood him to mean that it's going to take us time to get substitutes.

**Ozonoff.** It took only 30 days to get vinyl chloride out of the workplace.

**Joseph Alper** (Univ. of Mass. at Boston). As a chemist, I'd like to say that many classes of chemicals are known to be more likely carcinogenic than others. Sulphuric acid and other basic industrial ingredients are simple inorganic compounds which are not likely to be carcinogenic. Most of the carcinogenic ones, in fact, are chemicals that have been introduced recently as replacements for perfectly satisfactory materials that have been used for generations, even for millenia. Many of these carcinogens, in fact, have been introduced just for profit. The majority of byproducts of petroleum refining and plastics manufacturing, by the nature of their chemical structures, are likely to be carcinogenic. But uses are sought for them just the same.

**Ozonoff.** There's something I didn't make clear before. It's not always so complicated to find out whether a chemical causes cancer. Though it took the academic world a long time to determine that asbestos was carcinogenic, the life insurance industry knew that in 1918 when they stopped insuring asbestos workers.

**Richard Levins** (Harvard School of Public Health). There's a basic limitation on what you can do with a problem of this kind in a capitalist society. The pursuit of happiness on the part of a large company means the right to do whatever it likes to the environment until it can be specifically proved that someone is being killed by your molecule and not by that of another company down the road. This is part of the liberal world view that on the one hand is a list of problems, on the other hand a list of solutions, and we should build a one-to-one correspondence between them, the link being a sufficient budget. With unlimited funds you could establish some of these links. The real question, however, is not that of dealing with each molecule separately but that of evaluating the carcinogenic load of the environment and deciding that something should not be added unless there is a positive social reason for it. Not just asking if this particular molecule is less noxious than the average of the others already there.

**Jonathan King** (MIT). Research in the United States is organized by peer groups, committees of experts that look at grant applications and decide which investigators get money. The National Institutes of Health publish lists of those who sit on their committees. There's one committee called the Tobacco Research Council that is responsible for U.S. research on tobacco. Now, maybe you'd like to know why you have not seen article after article in the New York Times over the last 20 years with headlines saying "Scientists identify compound X as a potent carcinogen for the cells lining the bronchial tubes of your lungs." Though many such compounds are actually known, the Tobacco Research Council does not fund researchers who want to identify what tobacco smoke does to the lungs. You'll find that every single tobacco company is represented on this research committee and that it funds research on how to grow tobacco different ways. The result is that the New York Times published only statistical evidence that encourages the reader to say: "Somebody else gets cancer but not me." Very tight arrangements are made by the tobacco industry to make sure that NIH scientists do not get material support for publishing other kinds of reports. □

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Democritus represented figures as consisting of atoms and in this way reduced the continuous to the discrete. But the discovery of incommensurable intervals led to the abandonment of such a representation. Continuous magnitudes were no longer thought of as consisting of separate elements.

The contrast between the continuous and discrete in mathematics reappeared forcefully in the 17th century as the foundations of the differential and integral calculus were laid. Some thought of the infinitesimal as a real, "actually," infinitesimal particle of the continuous magnitude, like Democritus' atoms but now with an infinitely great number of such particles. Similarly, calculation of an area was understood as "the sum of the lines from which it was formed." The continuous was again reduced to the discrete. As a counterweight, there appeared, on the basis of Newton's work, the notion of *continuous* variables, of the infinitesimal as a *continuous* variable decreasing without limit. In the union of the discrete and the continuous, it was again the continuous that dominated.

But the development of analysis demanded further precision in the theory of variable magnitudes. In the 1870s there arose a theory of real numbers which represents an interval as a set of points. The properties of continuity were expressed in the structure of a set of discrete points that formed it. This conception led to immense progress in mathematics and became dominant. But again profound difficulties were discovered, bringing attempts to return on a new level to the notion of pure continuity. New points of view appeared for representation of intervals, for the concepts of number, variable and function. The development of the theory continues.

— Condensed from Aleksandrov, Kolmogorov and Lavrent'ev, *Mathematics: Its Content, Methods and Meaning.* MIT Press 1969, pp. 33-34.



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## DOES WAVE-PARTICLE DUALITY INVOLVE ANTAGONISTIC CONTRADICTION?

**Lester (Hank) Talkington**
**Editor, Science and Nature**

In the 18th century scientists were quite secure in their knowledge that light consisted of Newtonian corpuscles. In the 19th century the work of Young, Fresnel and Maxwell brought them to an even stronger conviction that light is nothing more than the energy of wave disturbances propagated in a pervasive material medium, the hypothetical ether. In the 20th century, the elaboration of Einstein's theory of light quanta and Bohr's complementarity principle has convinced scientists that light is inherently dual in nature, consisting of both wave and particle, depending on the experimental means by which it is observed.

My question is whether the prevailing 20th century concept is any closer to absolute truth than the concepts of previous centuries. In particular, I ask whether the concept of duality does not conceal within itself an antagonistic contradiction that creates the basis for its own overthrow. This is a physical question which I shall examine philosophically, directing my criticism only at theoretical models and conceptual interpretations concerning the meaning of empirical results. Recognizing, however, that the meaning of an experiment depends a lot on the theory, I will try to preserve due scientific caution while attempting to show the helpfulness of Marxist philosophy in examining the question.

There is no need to dwell on the earlier quantum theory and the much-discussed contradictions which lead to the uncertainty principle and the rejection of the principle of causality. These matters are handled well by David Bohm in his book *Causality and Chance in Modern Physics.* You'll find there a convincing Marxist critique of the prevailing quantum interpretation, showing how it leads to that ultimate of dead ends: the pretense to absolute knowledge. For my purpose it is more relevant to examine the contradictions of quantum electrodynamics (QED), the latest development of quantum theory and by far the most practical. QED has scored stunning successes in predicting the observed phenomena of electromagnetism and atomic physics, often with accuracy to six significant digits. Yet QED exhibits much the same basic contradictions as the earlier quantum theories.

Since QED is so effective, you may wonder why anyone worries about its contradictions. But that's what science is all about. The scientists most involved in using QED are often those most concerned over the contradictions they find within its theoretical structure. An excellent treatise describes the situation thus:

"Although it is a completely satisfactory theory within a definite field of physical phenomena, modern quantum electrodynamics has the important drawback that in order to remove the divergences which arise in the theory additional concepts must be introduced which are neither contained in the fundamental formulation of the theory, nor reflected in its basic equations. This state of affairs is apparently due to profound causes." [Akhiezer and Berestetskii, *Quantum Electrodynamics*. Interscience 1965, p. viii].

In simple truth, this very successful theory is plagued by *ad hoc* parameters that have to be chosen and adjusted to the particular problem in order to make the theory fit the real world. This is the overt form in which contradictions manifest themselves most crudely to scientific consciousness. Let us search for more subtle manifestations internally. What are the inner contradictions that produce this unsatisfactory theoretical situation?

Penetrating a little more deeply, we find that the photon has pretty much the same mystifying properties in QED as in previous quantum theories. For example, the photon does not exist as a particle until it interacts with an electric charge. Up to that moment it exists only as a wave function spread over space. From a materialist point of view, this is a basic contradiction, one that deeply disturbed scientists in the beginnings of the quantum era. We will come back to it later.

This is not the place to delve into the intricacies and artistry of the mathematical devices by which QED accomplishes its impressive feats of modeling a particle to behave as a wave and vice versa. It is well done, of course, and that's why QED is useful. For now, it is sufficient to see how the wave-particle contradiction was introduced in the initial conceptual foundations.

The essence of QED is the marriage of the photon to the Maxwellian wave. Two disparate concepts—the photon as a discrete bundle of energy—and the electromagnetic field as a continuous distribution of energy—were united in a mathematical ceremony known as quantizing Maxwell's equations. Thus the two became one. The wedding vows required, among other things, that the photon have zero mass. True, some authors prefer to say that it's only the *rest mass* that must be zero. I think this is just fudging because it is Maxwell's equations that deny the existence of mass in electromagnetic radiation. They describe the propagation of nonmaterial or massless wave wave disturbances through a conjectured ether. Though the hypothesis of the ether has been discarded, there has been no modification of the equations nor of the wave-motion concept they describe.

I am ready at this point to state more fully what I see as the basic philosophical question at issue. The wave function of a quantum photon is defined in QED as a Maxwellian wave. Maxwell's equations describe an electromagnetic field of waves radiating out into space, divorced completely from their source. Though the source loses mass in the process of radiation, the Maxwellian waves do not convey mass or matter in the literal sense.



They convey only energy in the same sense as sound waves or water waves. It is this mathematical analogy that deprives the photon of its mass in the radiation process.

So where does this put the photon? QED theory says that, since the presence of a photon can only be established by its interaction with an electric charge, the interaction must be determined by the values of the electric and magnetic field vectors of the wave at the point of interaction. Though these field vectors, by mathematical definition, constitute the wave function of the photon, their values are spread out over all space. The theory does not permit even the concept of a probability density for localizing the position of the photon as a particle. An important aspect of this contradiction is that the quantized field thus fluctuates *even in the absence of photons.*

One thing that becomes clear is that in this "duality" there is a very unequal relationship between wave and particle. The wave function is the tail that wags the dog. The photon as a particle is a sometime thing, a dependent variable that may be here or there though the uncertainty of its position doesn't really matter, since it isn't really *matter* until the wave calls it into existence.

My point should be clear by now: that the contradictions within QED arise from its non-materialist formulation based on Mexwellian waves. Now I'm quite aware that to raise such a question is a pretty heavy thing. I'm aware that Maxwell and Hertz gave us our first scientific insights concerning the inner processes of radiation. They told us what light is. I'm also aware that QED, based on the Maxwellian wave model, has brought us to a new higher level of scientific understanding concerning the nature of light. Nevertheless, I think that the Maxwellian wave model has served its purpose and now stands as a barrier to further progress. I think Maxwell's equations have their domain of validity where the intensity of currents and density of charge permit their treatment as a continuum. These conditions do not apply in the quantum realm.

Something new is needed. It would seem both physically and philosophically more consistent to start with the photon as the source of its own electromagnetic wave function. But it is not easy to get started on this new kind of quantum model because the great authority of Maxwell's waves seem to have inhibited creative exploration along this line.

I will close by noting that the very success of QED may provide the basis for developing such a new theory. Out of the very contradictions between the clumsy theory of QED and its elegant experimental results some new model for the photon must emerge. There are glimpses and hints here and there about the photon structure. In particular, there are signs that the photon itself must have a dipole structure that explains its properties. The trouble is that theorizing on new models has so far been very tentative and not incisive. I think that the reason for this is philosophical. Quantum science really has all the technology and data it needs for a new model, a new interpretation. What has been lacking is the dialectical materialist way of probing into the problem.

When a new theoretical structure does emerge to replace the anachronistic Maxwellian wave concept, I predict that it will explain the phenomena fo light simply and directly in terms of an electromagnetic particle with unambiguous mass, a photon that is clearly matter in motion.

AUDIENCE INTERACTION

**Steve Carlip.** (Somerville, Mass.) There are now pretty well known particles, the intermediate vector bosons, which behave exactly as the photon except that they have mass. They contain the same wave-particle duality as the photon. It seems to me that masslessness is not a fundamental part of the problem.

**Talkington.** But the photon is treated as unique in physical theory.

**Carlip.** Not any more. In gauge theory, originated by Weinberg and now accepted by something like 90% of elementary particle physicists, the photon is one of four particles which behave pretty much alike except for mass.

**Talkington.** I.m not a physicist but I understand that Weinberg's theory just incorporates QED, or at least accepts all of its conclusions. Maybe there's no contradiction with what I'm saying.

**David Schwartzman.** (Howard Univ.) I thought your idea of possible limits to the theory was good but I think it's incorrect to say that something is not material because it doesn't have mass. Lenin's definition of materiality is that of objective existence. It doesn't have any other presuppositions. We can't dictate to science about masslessness.

**Talkington.** The thing about Maxwell's equations is that they predict propagation of a disturbance without propagation of the mass that was radiated. As long as Maxwell's equations are used you do not have localization of energy, the photon is not there.

**John Venuti.** (Cambridge, Mass.) I don't know if I agree with your thesis that this concept of wave-particle duality is in fact holding us back. But I think the duality concept does show the limitations of our understanding of nature. On the other point you made, about matter and energy, Einstein said they are just the same, and that, in fact, you can't distinguish the two. In the later years of his life, he was trying to develop a unified field theory which would show that all forms of matter are just condensed states of energy. That's another example of how limited our knowledge is. But it does not exclude that we will at some point have the answers to these questions.

**Joseph Alpert.** (UMASS Boston) The photon isn't the only massless particle. There are two types of neutrinos that seem to fit with theory and are also massless. Is your objection to the whole of quantum mechanics, or just to the renormalization problems of quantum electrodynamics, or what?

**Talkington.** Essentially I refer to the whole, to the extent that quantum theory uses Maxwell's equations in formulating the wave phenomena. I'm saying that Maxwell's equations are not correct for the quantum domain.

**Alpert.** No one says they are. The vacuum fluctuations of QED certainly don't come out of Maxwell's equations yet they are effects well documented in the Lamb shift. Sure, it's a fanciful name that sounds like a mystical concept but vacuum polarization is mathematically based and it's certainly not in Maxwell's equations.



**Talkington.** I agree. The concept of vacuum polarization arises out of the mathematics of QED. The only way to explain it physically is to hypothesize the existence of virtual particles in the intervening space, something that had to be injected to explain why QED works. This is just one of the anomalies that bother people working in QED.

**Jonathan King** (MIT). I believe you're right that new theories will develop but it seems to me that you are placing them in a vacuum. All these theories develop in an actual historic context. Maxwell and Hertz developed their theories in the context of productive relations under capitalist industrialization. Next came the physics of the 20s to 60s, developments coming out of the contradictions between imperialism and socialism. I don't think the resolution you're talking about can take place until the primary political contradictions are resolved, until, say, the real energies of the physicists are released from military work.

**Talkington.** I will comment on this in the context of physics as existing within society but not being identical with society. A physical theory or theoretical structure has two contradictory aspects. One is the materialist empirical basis. The other is an ideological superstructure: the models and the interpretation. The two interact on one another and very often the mathematical formulation is a link between the two, reflecting both the empirical and the social-historic origins pf the theory. Interpretation is certainly greatly affected by the ambient social environment but they are not rigidly linked to each other. I don't think that new advances in physics have to wait for socialist revolution. By now, nearly half the world is socialist and this has not affected wave-particle duality. The problem has to be solved within the realm of physics and it can be solved there, by the physicists, with proper historical and philosophical analysis. This requires what Lenin called for, a partnership between the philosophers and the scientists. Now scientists are not inherently conscious philosophers. They are inherently materialist in their manner of working but not necessarily in philosophical ideology. The main purpose of Dialectics Workshop is to help make scientists more conscious of philosophical aspects of their work and philosophers better able to help scientists. This partnership has never been sufficiently achieved. In the Soviet Union they still struggle toachieve it. This is a worldwide struggle but the ideological environment today is different from what it was 50 years ago or 25 or even 10 years ago. I don't think we have to wait.

**Ullica Segerstrale** (Harvard). There is data showing that, among natural scientists, the physicists are the most politically radical. So there is hope for philosophical progress too.

**Author's addendum.** In a personal communication, Steve Carlip points out that my statement, "Maxwellian waves do not convey mass or matter in the literal sense," seems to deny the equivalence of mass and energy. I agree but insist that the contradiction is not mine and must reside somewhere in Maxwell's theory if not in QED where the quantized form of Maxwell's equations requires that the photon be a particle of zero mass but not zero energy. Perhaps the terminology is clumsy but I contend that an adequate theory will predict a photon with *particulate* mass equivalent to its energy. More on this in next issue. □

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# CHRISTOPHER CAUDWELL AND THE SECOND LAW OF THERMODYNAMICS

**Shaun Lovejoy (physics)**
**McGill University**

One of the many paradoxes of Christopher Caudwell was that he considered himself mainly a poet yet he also attained a solid grasp of the contradictions in modern physical theory. Marxist insight accounted for this wide-ranging comprehension.

Leaving school at 15, Caudwell worked at journalism, edited an aeronautics magazine, and wrote detective stories, apparently uninterested in politics. Then, at age 27, he became a Marxist, joined the local branch of the British Communist Party, and set for himself no less a program than that outlined by Lenin: "Communism becomes an empty phrase, a mere facade, and the Communist a mere bluffer, if he has not worked over in his consciousness the whole inheritance of human knowledge." In two short years, Caudwell accomplished an incredible amount of this program. His achievements became known only after he had volunteered for Spain and had died soon thereafter (February 1937) in battle against fascism. The manuscripts left behind showed an unusual breadth of knowledge of realms of aesthetics, literature, anthropology, psychology, philosophy and natural science.

One unfinished manuscript titled "Crisis in Physics" (1939) has received relatively little critical attention from scientists though J.D. Bernal (1954) praised Caudwell for "hitting the nail on the head so many times." The book deals interestingly with important and still largely unresolved questions of physics including the wave-particle contradiction, quantum mechanics, and general relativity. Here I will examine Caudwell's views on the second law of thermodynamics and the apparent contradiction between entropy and evolution. Caudwell's philosophical analysis of this subject concentrated largely on the role of ideology in physics. I propose here to contrast Caudwell's views with recent and relatively unspeculative explanations of this paradox: the work on non-equilibrium thermodynamics by Ilya Prigogine, Gregoire Nicolis, Paul Glansdorf and others; and the work of astrophysicist David Layser on the evolution of the universe—explanations that appear to elucidate the principle mechanism that enable physical systems, and indeed the universe as a whole, to produce both information and entropy simultaneously. My purpose is to pose obvious questions concerning the limits that philosophy can impose on scientific research, emphasizing the importance of exposing such ideological influences elsewhere in physics.



Caudwell's views on thermodynamics appear in his discussion of physical reality in all its ramifications. Unfortunately, this part of the book is really in the form of notes which are often repetitive and difficult to follow. Another problem was presented by his language and style. Caudwell is at once intense, fresh and vital. Seething with metaphors. As one critic put it: "Caudwell's style is Caudwell's way of seeing" (E.P. Thompson 1977). Though very original and perhaps truly "dialectical," this style often says or suggests more than it should. In what follows, I have attempted to bring out the more important of his arguments and the more specific of his conclusions on this particular topic.

Caudwell viewed reality as a system of interacting, continually developing and newly emerging domains, domains in the process of becoming, in the dialectical processes of transformation of quantity to quality and vice versa. He regarded physical law as "a feature of natural domain—or more correctly, the specification of a natural domain." As such, physical laws could only follow the tranformation of quality into quantity, or the "ingathering of likeness," since the transformation of quantity into quality brought forth a new level, a new domain, and thus contained elements which, by definition, were outside the purview of previously existing laws and gave rise to the existence of new laws. He thus concluded that the part of reality to which physics is applicable is that dealing with the production of likeness, the increase in quantity, or the increase in disorder. In short, the second law of thermodynamics defines the realm of physics, being the most general law of the transformation of quality into quantity, and thereby "it is a physical evolutionary transformation law, and as such, is the foundation of all higher evolutionary processes ... It explains that, taking the universe as a whole, becoming is a certain universal characteristic which is what we mean by Time as immediately experienced by us in the passage of past, present and future. This universal characteristic is that the present can in no circumstances become the past. Time flows. Newness emerges. All is becoming ..."

For Caudwell, there was no possible grounds other than ideological for the interpretation of the second law as the law of the "running down of the universe" or of the "heat death." Quality, newness, order were all created simultaneously but on a new level or domain. To account for the newness, new facts and new laws had to be found, thereby enlarging the scope of physics. But if order appears simultaneously with disorder, through processes which can be incorporated into physics only "after the fact," this new order will provide the basis for producing a new entropy: "Every increase in complexity makes possible an increase in disorder—a well furnished room can be more untidy than a monastery cell. Hence the disorder of entropy is artificially created ..."

Having sidestepped so far the question of specific mechanisms for producing order, what can Caudwell say about them from the general considerations outlined above? "Energy ... is the most generalized component of quality. Energy, the quantum, quantity, is the likeness in all quality ... " Thus, it is not surprising that, at thermodynamic equilibrium, where the production of entropy is at a maximum, the available energy is minimized, corresponding to a minimum production of order.

Similarly, with processes which increase order, we may expect a large flow of energy between new and old domains: "Thus the continual decrease of available energy between particles is matched by an increase in the available energy between systems or domains." Later we can examine Caudwell's anticipation of dissipative structures. Let us first see how close he came to finding specific mechanisms for the production of order

The law of entropy, he says, is statistical, i.e., it is the law of a large number of particles, stripped of all attributes that could distinguish them. The particles are specified as devoid of individuality, abstracted from the domains to which they belong. However, "this reduction of particles to units excludes their small difference, and this difference may always add and emerge in the effect as a big difference, as accident. This accident is however an aspect of neccessity, and means that in spite of physics, as it were, a new domain has been generated." Thus accident, chance, or, as we now conceive it, fluctuation plays a decisive role in the generation of new domians.

Not surprisimgly, this is as close as Caudwell came to explaining evolution. His solution is formally correct, demonstrating fairly well that mechanistic materialism, by stripping matter of all qualities except those of numbers and by the reduction of all physical relations to particles with no individual attributes, leads to the notion of a universe running down and to the necessity of regarding biological systems as exceptions to the second law of thermodynamics. Since such mechanistic conclusions are widely used for inappropriate and ideological purposes, it is important to see how Caudwell's concepts have been largely vindicated by the recent work of Prigogine and Layzer.

David Layzer (1975) starts with essentially the same picture of physical reality as Caudwell: an interacting hierarchy of approximately closed systems, each with a certain autonomy but, due to interactions with other domains, not completely self-determining. Starting at the fundamental level of elementary particles, Layzer seeks to determine the origin of the arrow of time, i.e., the origin of order and disorder. He argues that the arrow cannot come from the microlevel because there the laws of physics appear to be reversible. It must therefore come from special boundary conditions applying to an ensemble of particles whose regularities are in turn determined by higher laws, and so forth. For example, when an open bottle of perfume is placed in a room, the molecules of perfume disperse to fill the available space and do not return to the bottle. Of all the possible arrangements for perfume molecules in the room, that of all molecules being in a small bottle is exceedingly unlikely and may be regarded as a special boundary condition. The direction of time implied by this sequence is called the thermodynamic arrow, in contrast to the historic arrow implied by evolution.



Processes that display the thermodynamic arrow of time convert macroscopic information into microscopic information, e.g., when the perfume molecules disperse in the room, the information of their original confinement to the bottles is lost though, if we had followed the path of each molecule, it would have been converted into microscopic information. The special boundary conditions (the bottle) may be regarded as macroinformation as seen from a subsystem though it is microinformation for a higher domain in which various sets of boundary conditions are possible. The essence of Layzer's idea is this: to account for what's happening on the small scale you have to know what's happening on the larger scale.

Applying these concepts in a regression to the conditions at the beginning of the universe, he argues that the conditions then obtaining were a lack of detailed microscopic or macroscopic information—meaning that the universe was in thermodynamic equilibrium for the first microsecond, according to his model. He can thus refute Harlikar and Hoyle who start with a universe that is in a state of thermodynamic disequilibrium but continually approaches equilibrium and "heat death". Layzer's view is the exact opposite, that the universe started at thermodynamic equilibrium but, because of a Big Bang explosion, if you like, the dynamics pulled the thing apart; the rate of change was so great that thermodynamic equilibrium could not be maintained beyond the first microsecond. In contrast to some more slowly expanding cosmologies, thermal equilibrium between the matter and the radiation fields is never re-established. A universe at uniform temperature of "heat death" thus never occurs. In this way, the dynamics generate order and information; the universe can't get to the state of maximum entropy because of these dynamics. Thus it is possible for galaxies to form with a certain order initially and the whole process cascades down, leading to conditions of thermal non-equilibrium such as the Earth with its solar energy gradient. I won't say that this concept is completely accepted but I think it must be basically correct. It is important to note that Layzer has essentially the same idea as Caudwell concerning many different domains and levels of domains.

Of more interest, I think, for understanding the production of quality and order is the Prigogine (1978) discovery of a class of systems which exhibit two radically different kinds of behaviour. In one type of situation, close to thermodynamic equilibrium, there is a tendency to evolve toward a state of maximum disorder. In another situation, far from thermodynamic equilibrijm, with a state maintained by a large entropy flow to the environment, the system exhibits what Prigogine terms coherent behaviour. In order to reach a state of lower disorder than it started with, such a coherent system must expel entropy in the environment. In real physical systems, such as chicken eggs, this is observed as a high rate of heat production and dissipation where the opposite would be expected if the system started near thermodynamic equilibrium. Such systems have come to be known as dissipative structures. This dissipation of energy is in accord with Caudwell's philosophical argument that the available energy should be large for evolving systems, in contrast to the minimum available energy state for systems producing disorder at thermodynamic equilibrium.

The analysis of systems having two such differnt kinds of behaviour, according to Prigogine, requires nonlinear equations of the type that characterize, for example, certain kinetic laws and hydrodynamic systems. These are horrible things to deal with, even on a computer. There is no general theory. Though the Rene Thom (1975) work on catastrophe theory is looking into the kinds of discontinuities that arise in nonlinear equations it is still not a general theory. So far, not enough is known.

Prigogine's basic point is that, as the system gets further from thermodynamic equilibrium and comes near to the coherent domain, it reaches a point where molecular fluctuations can take it across the boundary (or bifurcation point, or discontinuity, or whatever). Near the point of crossover from the realm of thermodynamic disorder to the domain of coherence, molecular fluctuations play a critical role in the behaviour of the system. And these fluctuations are essentially random; they follow different laws than the macroscopic laws obtaining before. As the system goes over into coherent behaviour, it also becomes very dependent on the large scale structures. Most systems near thermodynamic equilibrium can be described pretty well by the normal macroscopic measures such as temperature, volume and pressure. But these are not enough when the system gets near to production of order or quality. Large things such as the size and shape of the vessel, that could be ignored before, now become critically important. There is a dialectical interaction between the higher and lower domains that was previously not significant.

Thus the system can evolve deterministically under control of macroscopic variables between bifurcation points but once near a bifurcation, random molecular fluctuations and large scale boundary conditions are decisive in determining its state. New laws are now required that describe the nature of the boundary conditions and of the fluctuations. Often, as in the case of hydrodynamic theory, it is impossible to determine the evolution of the system in any detail; only the statistical properties of the states can be estimated. The dialectics of chance, i.e., the fluctuations, thus play an essential role in the necessity of producing order.

We see that Prigogine is in close agreement with Caudwell's dialectical interpretation on most important points. First, the strong dissipation of energy by systems producing order or quality contrasts with the minimum dissipation of energy and production of disorder by systems near thermodynamic equilibrium. Caudwell predicted this on the basis that energy is the most general component of quality and of producing newness. Second, a system or domain can be relatively self-determined in the production of disorder, i.e., transforming quality into quantity. In the production of order, however, the behaviour of the system is critically influenced by the properties of the larger-scale domain and of the sub-scale domain, the latter depending in a fundamental way on events that are random from the point of view of the system itself. Caudwell described this as the effect of now-no-longer negligible differences between particles, which add up to a decisive role though appearing as accident in the larger domain. Thus, the new quality emerges on a new domain, giving rise to qualitatively new laws not reducible to the old laws. Caudwell stressed the need for physics to accommodate new laws in order to be able to describe the evolution of the new domain. Finally, since order can be created far from equilibrium via dissipative structures which expel entropy into the environment, order is produced simultaneously with disorder, in agreement with rather than in violation of the second law. This dialectical relationship between order and disorder, quantity and quality, was fundamental to Caudwell's entire way of thinking.



To conclude, I think that Caudwell provides a very useful model for the use of philosophy by the radical scientist in combatting professional obscurantism, false interpretations and reactionary ideologization of science. He shows us that, even when the detailed physical mechanism underlying a physical law or phenomenon remains unknown, it is possible to defend the materialist viewpoint successfully. There is no excuse for refraining from the battle, nor from mastering Marxism as a tool for the struggles within science.

I hope I have also shown that Caudwell's work in science is somewhat more interesting and significant than has been generally recognized and thereby have helped stimulate new appraisals of his work on other contemporary issues of physics.

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### *AUDIENCE INTERACTION*

**Joseph Alper.** (U MASS Boston) The question of how living things on earth can create order out of chaos has a simple answer: we don't live in an isolated system; we're maintained by the sun and the sun has a huge amount of energy. The questions about heat death are totally academic because the sun is going to last another five billion years.

Either entropy or energy can be considered the fundamental variable [of a system]. It's interesting that energy is always treated as the fundamental variable ... because energy is what's basic to the capitalist system.

On the other hand, for living systems, for structure and organization, entropy is always the interesting quantity. But we never talk about it. Entropy is this mysterious philosophical thing you get in studying the origin of the universe, the Big Bang. But entropy has nothing to do with that. The principles of the increase of entropy in biochemical reactions, in life, are quite well understood.

They're not far from equilibrium. The temperatures and other gradients are very small. Thermodynamic fluctuations have essentially little to do with this. I think it's all needless sophistication.

**Lovejoy.** I agree with certain of your points. But it's not enough to say simply that the earth is not in isolation, not in thermodynamic equilibrium. For example, the principle of minimum available energy can explain how crystals form through a conflict between energy and order. The point is to explain how you get biology. Without qualitatively new laws to explain it, you have zero probability.

**Alper.** It's been brought up here that by using dialectics you can have a materialist explanation for the origin of life. That's what Oparin did. He showed it without introducing new laws, just using ordinary chemistry and realizing that conditions before life are not the same as conditions after life [has come into existence].

**Jonathan King.** (MIT) The physicists leave out the fact that the origin of life is an event in the history of the physical universe. Trying to understand what's going on in the universe, the physicists also leave out the fact that society exists and that society transforms nature. People come up with new ideas ... for tapping the rotational energy by a planetary pipe, for moving planetary life to another place. We have to understand that spreading human society to other planets will transform the universe in ways not foreseen by conventional physicists who separate life from the rest of the universe (as some biologists also do).

**David Schwartzman.** (Howard University) I think the question of the origin of life is still open. Not that it's unknown; Oparin showed how chemical evolution could proceed under plausible conditions for the emergence of living systems on earth. But I think it's wrong to say that irreversible thermodynamics could not contribute to our further understanding.

**Lester Talkington.** (Science and Nature) The law of thermodynamics is certainly valid for a closed system, but we don't know the whole open system of the universe. Any kind of formulation that predicts a specific end to the universe has to be based largely on ignorance. We need to go ahead investigating the mechanisms so we can know more.

**Lovejoy.** Yes, and, in the meantime it's comforting to know that there is specific evidence as well as philosophical conclusions to show that the heat death prediction is wrong. □

*Science as a Social and Historical Process* ——————————————————

**It should be noted that there is a difference between universal labour and co-operative labour ... Universal labour is scientific labour, such as discoveries and inventions. This labour is conditioned on the co-operation of living fellow-beings and on the labours of those who have gone before. Co-operative labour, on the other hand, is a direct co-operation of living individuals.**

**— Karl Marx, *Capital*, III, 124.**



*Dialectics Workshop*
*Columbia University*
*19 May 1978*
*Contributed paper*

## THE DIALECTICS OF THE PROBLEM OF CETI

**(Communication with Extraterrestrial Intelligence)**

**David W. Schwartzman (geology) Howard University**

**Comment: McGill Science Discussion Group**

**Lenin**: "We ought to dream!" (*What is to be done*, Ch. 5.)

**Engels**: "However many millions of suns and earths may arise and pass away, however long it may last before conditions for organic life develop, however innumerable the organic beings that have to arise and to pass away before animals with a brain capable of thought are developed from their midst, and for a short span of time find conditions suitable for life, only to be exterminated later without mercy, we have the certainty that matter remains eternally the same in all of 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." (*Dialectics of Nature* N.Y. 1940 p 24.)

Interest in the possibility of extraterrestrial intelligent life (ETI) has mushroomed in recent years, sometimes assuming fantastic forms such as the UFO cult of "Bo and Peep" which promised its adherents a trip aboard a flying saucer if they gave up all their worldly possessions. Currently the movie "Close Encounters of the Third Kind" is capitalizing on the interest in ETI sparked twenty years ago by sputnik. Behind the sensational treatments there is a serious science in the birth process—the science of CETI. In 1966 a book was published in the U.S. entitled "Intelligent Life in the Universe," representing a unique collaboration of the Soviet astrophysicist Shklovsky with the U.S. astronomer Sagan. The collaboration expanded in the era of detente into the Armenian conference on CETI in 1971 (Sagan 1973).

The science of CETI, which is in the process of integrating virtually all the physical and social sciences, is naturally highly speculative since it has only one example at present—us! Yet, it treats as its object a subject which stirs the imagination of poets and scientists alike. Actual evidence of another intelligence somewhere in the universe would surely rank as the most astounding discovery in human history. The purpose of this paper is to examine some of the insights into the problem of CETI that I believe Marxist thought has to offer and to relate them to a number of critical philosophical questions, some classical (e.g., "what is our place in the universe?"), others more directly related to the potentially powerful heuristic role of materialist dialectics. Some of the philosophical problems that come to mind include 1) the process of development and integration of the natural and social sciences, 2) the status of the dialectical category of possibility and reality, 3) the similarities and differences between historical materialism and the so-called historical sciences of nature, and 4) ideological influences in scientific research.

I have discussed elsewhere some of my views on the strategy for CETI (Schwartzman, 1977).

Dialectical materialism has been an obvious stimulus to many of the fields that relate to CETI, for example, the problem of the origin of life with Oparin, Haldane and Bernal who made pioneering contributions, acknowledging their debt to Marxist thought (Graham, 1972, ch. 7). Dialectical materialism, as a generalized metascience uniquely rooted in the knowledge of science (Schwartzman, 1975), can be expected to play an important role assisting a fruitful interaction and synthesis of the natural and social sciences relevant to CETI. These sciences range from astrophysics to linguistics (e.g., how do we communicate with an alien intelligence). In fact, the Armenian CETI Conference was organized around the parameters of the Green Bank equation:

$$N = R_{\star} f_p n_e f_l f_i f_c L$$

where N is the number of advanced civilizations in the Galaxy, $R_{\star}$ the rate of star formation, $f_p$ the fraction of stars with planetary systems, $n_e$ the number of planets in each planetary system with conditions favorable to the origin of life, $f_l$ the fraction of such planets on which life does develop, $f_i$ the fraction of these planets on which intelligent life with manipulative abilities arises, $f_c$ the fraction of these going to a communicative level and L the mean lifetime of the advanced civilization.

Each session of the conference was essentially concerned with one or a group of the natural and social sciences. In particular, the dialectics of the emergence of a theory of cosmic civilizations could illuminate our own historical development, much as terrestrial meteorology can be deepened from the observation of "weather" on Venus, Mars and Jupiter.

I will now outline what I believe to be a somewhat different approach to the problem of CETI than has been published from a Marxist perspective. The assumption of "mediocrity" (Shklovsky and Sagan, 1966; see chapter 25) or ordinariness of our immediate surroundings is an assumption of averageness in terms of the time (4.5 billion years) of our technical civilization's appearance after our planet's formation, as well as the general couse of biological and social evolution. This assumption is supported by first of all the demonstrable uniformity of the laws of physics and chemistry throughout the detectable universe. The sun is a G2 yellow dwarf, not a particularly rare type of star in the galaxy. The extension of the assumption to the biological and social levels is more speculative, but is consistent with scientific knowledge of evolutionary processes. More about this later. In any case, it is highly likely that, if we are not alone, virtually all civilizations in the galaxy are much more advanced than we, since any civilization in advance of us by extremely small periods on an astronomical scale (e.g. 1000 years) would have to be on a qualitatively higher level.



Note that I do not assume that very different forms of life or histories of social development could not exist, but only that our example is not very different from the most common cases in our galaxy. Authors (e.g., Monod, 1971) who argue for the uniqueness of life on Earth based on the "laws of chance" are ignoring the prevalance of the terrestrial elements in the galaxy and the necessary conditions for their molecular evolution, and the substantial scientific research on the origin of life. A general misunderstanding of the dialectical category of possibility and reality, confusing it with animistic teleology, is the essence of Monod's polemic against Engels and dialectical materialism. Shklovsky (1978a) expresses his point of view as follows:

> It takes an extremely rare coincidence of a tremendous number of exceptionally favourable factors to trigger off the process leading to the origin of life. More than that, we still cannot say clearly and precisly what circumstances led to the origin of life on our planet. There is a vast abyss between the chemical compounds necessary for the origin of life and the living organism, however simple, consisting of these compounds. Even the most primitive bacterium is a miracle, if only because it is a part of the evolutionary process which was crowned by homo sapiens.

But in Shklovsky and Sagan (1966) we find: "the production of self-replicating molecular systems is a forced process which is bound to occur because of the physics and chemistry of primitive planetary environments." They estimate $f_l$ as approximately unity.

The science of CETI advances estimates on the statistical probability of the emergence of cosmic civilizations based on the implicit recognition of the dialectical unity of possibility and reality as a general law of development in nature and society (Sheptulin, 1978). The exceedingly low probability , for example, of the random assembly of a DNA molecule from its constituent atoms is irrelevant to estimating the probability of the origin of life on Earth or another planet with similar conditions, especially given the allowable time scale of millions of years. Modern research on this question envisions the step by step synthesis of more and more complex organic molecules and states of organization by pre-biotic chemical evolution leading up to the emergence of a self-reproducing, relatively stable entity—the first living thing. For example, Dickerson in his 1978 survey says:

> The broad goal is to arrive at an intellectually satisfying account of how living forms could have emerged step by step from inanimate matter on the primitive Earth. That goal appears to be in sight.

Thus each stage in this process of pre-biotic evolution opens up the possibility of the next stage being realized up to the emergence of life. Engels in his genius anticipated this unity of possibility and reality in the infinite but causally connected potentialities of matter.

Given our "averageness" I propose that historical materialism, as the theoretical science of the evolution of social formations, is a guide to the probable course of development of the average extraterrestrial civilization. Thus, the emergence of a tool-making capability (exhibited by a number of extinct and living primates) laying the basis for the modes of production and the birth of social formations would be a general, usual feature of development in the cosmos where intelligence has evolved, and further has probably played a significent role in accelerating its development (see Andreyev, 1977). Gindilis (1972) has proposed the category "cosmic civilization":

> Our own civilization on Earth may be regarded as a particular instance of this phenomenon, as one of the cosmic civilizations. Such an approach is very important and may prove highly fruitful in gaining an understanding of the nature of our civilization and the nature of human culture.

Shklovsky and Sagan estimated on the basis of plausible, though admittedly very speculative reasoning, some 106 cosmic civilizations exist in our galaxy alone. In fulfilling this function as a theory of cosmic civilization (cf. Kaplan's, 1969, "exosociology") historical materialism becomes analogous to the historical sciences of nature, geology and biology. Earth geology has already become the basis of planetary geology with the exploration of the solar system. Biology is perhaps very close to being generalized as exobiology (has Viking found life on Mars?).

We must now complement (or develop) the theory of historical materialism with the newly emerging science of no-ogenics, the theory of the interaction of society with nature (Kamshilov, 1973). Katsura and Novik (1977) have referred to this as the "ecologisation" of science. An object of this integrated science is the possibility of ecological catastrophe, which may even lead to the extinction of civilization. The threat of catastrophe from nuclear war or ecological collapse is most likely to occur in the epoch of transition from capitalism to communism, since the highest stage of class society provides the technological basis for substantial adverse alteration in the global environment, and the emergence of transitional societies (socialism) to communism provides the necessary conditions for its avoidance even on a planet with mixed socio-economic formations (peaceful coexistence). Those civilizations that pass this critical juncture successfully emerge as planetary civilizations, with the "entrance requirements" of the Galactic Club. Bernal (1967) posed this problem as follows:

> There is a possibility that the oldest and most advanced civilizations on distant stars have in fact reached the level of permanent intercommunication and have formed, as it were, a club of communicating intellects of which we have only just qualified for membership and are probably now having our credentials examined. In view of the present chaotic political and economic situation of the world, it is not by any mean certain that we would be accepted.

Of course, allowing the possibility that some civilizations may not successfully pass through the epoch of nuclear weapons, including our own, distinguishes historical materialism from vulgar economic determination or Hegelian perversions of Marxism (as forms of teleological thinking).

What is the time scale for entrance to the Galactic Club once a planetary civilization emerges? I argued (1977) that entrance may take only a few hundred years after a civilization is communicative (we have been inadvertently since the invention of the radio, at least to those possible civilizations



nearby with powerful receivers), and further that we are very possibly under surveillance now by ETI, given the probable ease of galactic expansion by an advanced civilization. Ironically, the very failure to pick up signals of ETI origin by radio-telescopes, though the search has barely begun, would be consistent with this view. Thus, the success of CETI may well depend on our terrestrial political practice, in eliminating "obsolete political-economic formations" namely capitalism. Shklovsky's (1978b) conclusion of our practical solitariness" in the universe leads him to similar goals based on our being a "vanguard" of matter in the universe: "The impermissibility of atavistic social institutions, senseless and barbarous wars and the suicidal destruction of the environment becomes crystal-clear." See later discussion of his views.

The recent literature on the probable intra-galactic expansion of advanced civilizations (Hart, 1975, Jones, 1976) refers to the "colonization" of the galaxy. This acceptance of imperialist ideology extraterrestrially extrapolated is of course notorious in bourgeois science fiction (eg. "Star Wars"). As I argued in response to these authors (Schwartzman, 1977) a more likely strategy of advanced civilizations, particularly if they are "federated" into a Galactic Club, would be surveillance and eventual contact. In a recent paper Shklovsky (1978b) has a much more pessimistic view as to the occurrence of other "mind-endowed life" in the universe. His arguments cannot be considered in detail here, but center around the obvious absence (in spite of Van Daniken's fantasized archeology) of colonization à la Hart, who is referenced in his paper. His characterization of the supposed miracle of the emergence of life from non-living systems on Earth has already been discussed. Sagan on the other hand (1978) remains much more optimistic:

> Why are they not here? The temptation is to deduce that there are at most only a few advanced extraterrestrial civilizations either because we are one of the first technical civilizations to have emerged, or because it is the fate of all such civilizations to destroy themselves before they are much further along. It seems to me that such despair is quite premature ...
>
> Personally, I think it far more difficult to understand a universe in which we are the only technological civilization, or one of but a few, than to imagine a cosmos brimming over with intelligent life.

Ironically, I believe Sagan has maintained more of a dialectical materialist position here, though I suspect unconsciously, while Shklovsky has retreated from one. An objection can be made to this statement to the effect that a dialectical materialist stance in philosophy cannot dictate a scientific conclusion from an a priori basis. I agree, for it is precisely on this basis that Shklovsky has retreated. Though the ideological influences on his thinking are obscure, he has taken up the mechanical materialist stance of Monod, while justifying the present lack of official contact of ETI by the most pessimistic assessments of its probability of existence. Efremov's *Andromeda* is a fictional projection of the idea that historical materialism is a theory of cosmic civilizations and a rejection of the dominant ideology of western science fiction already referred to. (There is an interesting and informative but uneven critical study of Efremov by the creationist (!) Grebens (1978).). From a Marxist perspective one should recognize that what is at stake here is not the sympathies of the science fiction enthusiasts but the ideological struggle between our futurology and that of the bourgeois world view. Embedded in this world view are the mystical cults, the counter-culture alternatives, the technocratic solutions of bourgeois futurology (eg. space colonies as a solution to a so-called overpopulation), all derivatives of the dominant ideology of the putrescent late stages of state monopoly capitalism. In the ideological struggle all aspects of a culture become the battleground for hegemony.

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## COMMENTARY: ETI, An Alternative Perspective

The following constitutes our collective impression of the ETI question, particularly as discussed by Schwartzman (S). None of us claims expertise in this field but, as scientists, we want to express our perception of the problem.

The fact that first struck us about the ETI literature was that, virtually independent of orientation, most authors proposed specific values for N (the symbols used here are the same as those used by S), which lay in the range of $10^4$ to $10^9$ in a galaxy of $10^{11}$ stars. As this seemed to be the first link in a chain of increasingly speculative reasoning, we propose to investigate it briefly.

The apparent mathematical precision of the Greek Bank equation is deceptive, since it contains several parameters which, given the present state of human knowledge, cannot be estimated within acceptable limits. This is true because 1) we don't know if the Green Bank parameters are physically meaningful (i.e. correspond to possible branches in life's evolutionary tree) and 2), even if we are dealing with the correct parameters, we have no definite way of estimating any of them, with the exception of $R_*$ and $f_p$, which can be estimated from astronomical data. Furthermore, the probable interdependence of the parameters and the errors involved in their estimation leads to an unacceptable amplification of the uncertainty. Thus, while it seems unlikely that we are truly unique (alone in the universe). this possibility cannot be excluded on the basis of present evidence.

As the considerable disagreement in the literature shows, the non-astronomical parameters can hardly even be guessed reasonably. The speculation involved naturally leads to a heavy emphasis on philosophical considerations. For example, while S finds Shklovsky (1978) guilty of retreating from a dialectical materialist position by adopting a more "pessimistic" value of N, in light of the evidence one could equally accuse S of a similar error in adopting an overly optimistic one. Clearly, when no firm evidence exists, the same philosophical basis can lead to radically different conclusions! Another way of viewing this is that no amount of philosophical considerations of the dialectic between possibility and reality can serve to supply the missing data. Only if and when a detailed understanding of chemical and biological evolution emerges can there be certainty of change in the "status" of the dialectical categories involved.

Similar considerations apply to the other points referred to by S. As exciting as it would be to develop an exo-biology, and exo-sociology, or any other exo-ology, no amount of speculation will fill these categories with significant content. This leads us to a more serious point in which we agree with S, that an important philosophical problem illuminated by ETI is the problem of ideological influences in scientific research. While S quite rightly castigates the theorizers of interstellar imperialism, extraterrestrial over-population, and galactic energy fetishism, we cannot agree with his method of Marxist refutation. One cannot refute the projection of western ideology into the voids of space by a similar projection of socialist ideology. The belief in extraterrestrial humanitarianism implicit in Bernal's "Galactic Club" concept is no less ideological than the western extraterrestrial colonization one.

While the western view is based on a futurology in which antagonistic contradictions are central, the views of Bernal and S are based on one in which the contradictions are completely superseded with the advent of socialism. But the experience of Stalinism, Maoism and the recent invasion of Vietnam provide sobering evidence of the contradictions that can still develop within the socialist movement. In reality, the founding fathers never hypothesized a complete end to social antagonism. They did predict a qualitative change, a progression in the true sense of the word, and we believe correctly so. However, unless we speak of the end of history itself, it is hard to conceive of any society which has no basis for change, i.e., no contradiction or conflict. To summarize: the ETI discussion is informative, not so much about ETI for which nothing definite can be said, but about TI, about which much can and should be said, not only about the capitalist but also the socialist varieties.

Perhaps it is worth dwelling a bit longer on the last point. While socialists are naturally sensitive to capitalistic ideological intrusions, especially in scientific domains, they are not always sufficiently self-critical. We feel that ETI is a case in point. Here, the influence of the tremendous optimism needed to build socialism has eveidently given Soviet and other ETI enthusiasts a justification for its extension to completely and unimaginably different contexts. While all socialists may sincerely hope that ETI will behave according to Socialist precepts, they must recognize that such a hope is no more than a hope, unless it is grounded solidly in real knowledge,

We thus feel that it is important to criticize ETI not from the perspective of one ideological speculation versus another but from the point of view of idealist ideology versus science. After all, if not ETI itself, then its reflection in popular consciousness (present UFO-ology) is part of a dangerous current of pseudo-science and mysticism that must actively be fought against by those who believe in the liberating power of knowledge. For if Bernal and S are taken seriously, that ETI surveys us constantly and waits for us to eliminate "chaotic political-economic formations," is it not logical to assume that ETI is capable of doing the elimination for us? It would seem difficult to separate the ostensibly materialist Bernal–S hypothesis from its idealistic UFO counterpart: that the hand of God is saucer-shaped. If our analysis is correct, then socialists should recognize ETI discussion as a variety of futurology and should analyze it as such. This is all the more important since ETI-ology has a close relative in UFO-ology, which has a variety of other close relatives.

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*A statement from the mid 1930s shows basics haven't changed*

## FREDERICK ENGELS AND SCIENCE

### J. D. Bernal (1901-1970)

**On the usefulness of Marxist dialectics in thinking about processes of science**

We reproduce the text of a long-out-of-print pamphlet that commemorated the fortieth anniversary of Engel's death. A foreword, presumably by R. Palme Dutt, editor of Labour Monthly (London) which published the pamphlet, tells the point:

> The author [Bernal] holds that Engels, the close collaborator of Karl Marx, developed methods which are essential today for any further advance in the understanding of science and its utilization for human welfare. As he says, these methods have been neglected in the past, but they seem to us now in the twentieth century far more fresh and filled with understanding than those of the professional philosophers of science in his day... Readers from all circles will find an extraordinary living interest in Mr. Bernal's exposition of how the dialectical materialism of Engels enables new light to be shed on all the problems of the day.

At the time he wrote this, John Desmond Bernal had an M.A. and was the assistant director of crystallography research at Cambridge University, working on the structure of metals, hormones, vitamins and proteins. He had been greatly stimulated by contemporary Soviet works recently made available in English, especially *Science at the Cross-roads* (1931) and *Marxism and Modern Thought* (1935). This essay foreshadows his own tremendous work *Science in History* (1954) in which Bernal applied dialectical and historical materialism with such seminal results.

*Note.* Bernal followed the style of that day where he refers to a materialist *dialectic* (singular form). Today the general usage is the plural form, as in *Dialectics of Nature.*

# ENGELS AND SCIENCE

## By J. D. BERNAL

IF Engels had not been the constant companion in arms of Marx in the revolutionary struggles of the 19th century, there is no doubt that he would be remembered chiefly as one of the foremost scientist-philosophers of the century. It was an ironical tribute paid to the correctness of his views as to the relations between politics and ideology that he suffered complete neglect from the scientists of the Victorian age. But time now has taken its revenge, and Engels' contemporary views on 19th century science seem to us now in the 20th far more fresh and filled with understanding than those of the professional philosophers of science of his day, who for the most part are completely forgotten, while the few that linger on, such as Lange and Herbert Spencer, are only quoted as examples of the limitations of their times. It would, of course, be wrong to consider Engels' scientific achievement apart from his association with Marx. It was through Marx's influence, and by the methods of dialectical materialism they evolved together from Hegel's dialectic idealism, that he achieved the possibility of criticising and interpreting science in a manner which was not open to his predecessors.

### *Engels as a Scientist*

It is often said by those anti-Marxists who never trouble to read the original writings that the scientific knowledge of Marx and Engels was superficial ; that Engels, for instance, sought in later life for scientific justification for the dialectical laws that Marx had introduced into economics. This is a complete misreading of the facts. Engels' interest in and knowledge of science was deep and early. It ran through all his philosophical and political studies. In an essay as early as 1843 (quoted in the Marx-Engels, Selected Correspondence, p. 33), he shows a grasp of the fundamental connection between science and productivity that was to run through all his later work :—

> . . . . yet there still remains a third factor—which never counts for anything with the economists, it is true—namely science, and the advance of science is as limitless and at least as rapid as that of population. How much of the progress of agriculture in this century is due to chemistry alone, and indeed to two men alone—Sir Humphry Davy and Justus Liebig ? But science multiplies itself at least as much as population : population increases in relation to the number of the last generation ; science advances in relation to the total amount of knowledge bequeathed to it by the last generation, and therefore under the most ordinary conditions in geometrical progression too—and what is impossible for science ?



Engels to the very end of his life not only made use of the science he had learnt at the University, but kept up with extraordinary keenness and understanding his interest in the scientific discoveries of his times. Far from being prejudiced by any preconceived theories, he was more open to accepting new ideas than were the professional scientists. In a letter to Marx in 1858, he shows himself prepared to accept beforehand the idea of transformation of species which Darwin was to publish in the next year (Marx-Engels, Correspondence, p. 114). In one passage he almost hints at the idea of evolution, derived from the Hegelian idea of transformation of quantity into quality :—

> So much is certain ; comparative physiology gives one a withering contempt for the idealistic exaltation of man over the other animals. At every step one bumps up against the most complete uniformity of structure with the rest of the mammals, and in its main features this uniformity extends to all vertebrates and even—less clearly—to insects, crustaceans, earthworms, etc. The Hegelian business of the qualitative leap in the quantitative series is also very fine here.

A few months later, when Darwin's " Origin of Species " appeared, Engels and Marx together acclaim it as putting an end to teleology in the natural sciences. Already Engels on December 12, 1859, exactly four weeks after the publication of the first edition, writes to Marx : " Darwin, whom I am just now reading, is splendid," and Marx writes in reply : " Although it is developed in the crude English style, this is the book which contains the basis in natural history for our point of view."[1]

If we contrast this attitude to that of the official philosopher of science and physicist, Whewell, a great derider of Hegel, who was at the same time urging that Darwin's book be not accepted by Trinity College Library, we can measure the greater breadth and penetration which their philosophical outlook had given to Marx and Engels. It was the same with all the significant ideas which science was developing. The great physical and chemical advances of the century, particularly the conservation of energy and the development of organic chemistry, were also recognised and carefully studied by Marx and Engels. In his approach to science, Engels cannot be said to have been an amateur. In Manchester, where he spent most of his life, there was a very lively scientific life with which he freely mixed, and, in particular, he had as his intimate friend Karl Schorlemmer, the first Communist Fellow of the Royal Society, and one of the most distinguished chemists of his time.

The width of Engels' scientific knowledge can be fully appreciated only from a study of his great unfinished work, *Dialectic and Nature.* In it different sciences are treated comprehensively and critically. It is easy to see from the authorities cited how close Engels was to contemporary developments in mathematical, physical, and biological

[1]Quoted by V. L. Komarov in *Marxism and Modern Thought*, p. 193. See also Marx-Engels, Correspondence, Letter 49.

sciences, to say nothing of sociology and economics. He even includes a short and amusing chapter on psychic science.

*Engels on the History of Science.*

From the start Engels was able to unify his conceptions of science in such a way that he could naturally assimilate new developments as they appeared, and that without any of the wilder flights of such scientific philosophers as Haeckel or Herbert Spencer, but in an extremely sane and balanced way. The secret of this power lies in the materialist dialectic which he used in his analysis of the results of science. It was from Hegel that he learnt to appreciate, not things, but processes, and he always looked at the position which science had reached at any time in relation to its historical background. This is clearly seen in his essay on Feuerbach, where he traces the history of materialist philosophy in relation to the development of science and productive methods. For instance, he says :—

> But during this long period from Descartes to Hegel and from Hobbes to Feuerbach, the philosophers were by no means impelled, as they thought they were, solely by the force of pure reason. On the contrary. What really pushed them forward was the powerful and ever more rapidly onrushing progress of natural science and industry. Among the materialists this was plain on the surface, but the idealist systems also filled themselves more and more with a materialist content and attempted pantheistically to reconcile the antithesis between mind and matter. Thus, ultimately, the Hegelian system represents merely a materialism idealistically turned upside down in method and content. . . .
>
> The materialism of this last century was predominantly mechanical, because at that time, of all natural sciences, mechanics and indeed only the mechanics of solid bodies—celestial and terrestial—in short, the mechanics of gravity, had come to any definite close. Chemistry at that time existed only in its infantile, phlogistic form. Biology still lay in swaddling clothes ; vegetable and animal organisms had been only roughly examined and were explained as the result of purely mechanical causes. As the animal was to Descartes, so was man a machine to the materialists of the eighteenth century. This exclusive application of the standards of mechanics to processes of a chemical and organic nature—in which processes, it is true, the laws of mechanics are also valid, but are pushed into the background by other and higher laws—constitutes a specific but at that time inevitable limitation of classical French materialism.
>
> The second specific limitation of this materialism lay in its inability to comprehend the universe as a process—as matter developing in an historical process. This was in accordance with the level of the natural science of that time, and with the metaphysical, *i.e.*, anti-dialectical manner of philosophising connected with it. Nature, it was known, was in constant motion. But according to the ideas of that time, this motion turned eternally in a circle and therefore never moved from the spot ; it produced the same results over and over again. (*Feuerbach*, pp. 36 and 37.)



As a historian of science Engels is particularly distinguished. He was the first to understand with Marx the close relation between the development of scientific theory and of productive methods. Much of what now passes for new in the interpretation of historical science is to be found in the pages of *Dialectic and Nature.*[2] He notices, for instances, that the theory of heat did not develop from pure thought, but from a study of the economic working of steam engines, and comes to the conclusion : " Until now they have only boasted of what production owes to science, but science itself owes infinitely more to production."[3] In particular he shows how the metaphysical and statical attitude of the 18th century materialists based on Newton was broken down in favour of a view which reflects, though unconsciously, a dialectical progress : " The beginnings of revolutionary science faced a through and through conservative nature, in which everything is to-day as at the beginning of the world, and will be to the end of the world the same as it was at the beginning."[4] The breaches made in this outlook he indicates as, first Kant and Laplace's nebular hypothesis, second the development of geology and paleontology, third chemistry, which can synthesise organised substances and whose rules hold just as much for the processes of life, fourth the discovery of the conservation of energy, fifth Darwin's evolutionary theory, and sixth the synthesis of all the processes affecting life, animal ecology and distribution. The significance of the break is described as follows :—

> It was not the scientists but the philosophers who made the first breach in this fossilised outlook. In 1755 appeared Kant's " General Natural History and Theory of the Heavens." The problem of the first impulse was here set aside. The earth and the whole solar system appeared as something *become* in the course of time. If, before the appearance of this thought, the overwhelming majority of scientists had not felt the fear expressed by Newton in his warning " Physics, Beware of Metaphysics ! "[5]—then they would have drawn from this single discovery of genius by Kant such consequences as would have saved them infinite errors along circuitous paths, and an immense quantity of time and labour expended in a false direction. In Kant's discovery lay the germ of all further progress. If the earth was something which had become, then all its present geological, climatic and geographical condition had become also, its flora and fauna as well, and it must have

[2]Marx and Engels Archives (German edition) Vol. 2, pp. 173, 194, et seq.

[3]M.E.A., Vol. 2, p. 195.

[4]M.E.A., Vol. 2, p. 175.

[5]The use of the word metaphysical in Marxist literature is apt to cause confusion at first reading. The accepted popular use of the word is to connote assumptions which cannot be verified by concrete experience, generally, also somewhat vague and mystical assumptions. This is the sense in which it is used here and also the sense in which Marxism itself is said to be—quite wrongly—metaphysical. The Marxist use of the word, however, is more specialised. As can be seen from the quotations in this pamphlet, it is used only for a class of assumptions and categories that are abstract, fixed eternal and capable of absolute contradiction, such as the categories of Aristotelian logic or pre-relativistic physics. In contrast to these are the fluid dialectical categories.

a history not merely in space, but in time also. (Quoted by V. L. Komarov in *Marxism and Modern Thought*, p. 205. See also M.E.A., Vol. 2, p. 244.)

As a result of these movements of thought, Engels says :—

> The old teleology has gone to the devil, but now we have the knowledge that matter in its perpetual circulation moves according to laws that at certain stages—now here, now there—necessarily produce the thinking mind in organic existence. (M.E.A., Vol. 2, p. 175.)

Engels' concept of nature was always as a whole and as a process. He escaped the specialisation which even in those days made it impossible for a physicist to understand biology or vice-versa, and he laid down a general outline of this process which can still be the basis for an appreciation of the results of scientific research.

He never had the opportunity to put down in one place his view of this universal process. The main outlines can be seen in *Anti-Dühring*, or even better in the shortened form of *Socialism, Utopian and Scientific.* But for its full appreciation in this country we shall have to wait until the publication in English of *Dialectic and Nature.* Throughout Engels wages war on metaphysical ways of thinking in science, with its fixed categories and its sharp distinctions between cause and effect, structure and behaviour, identity and difference, whole and part.[6] These are not so much invalid as valid only in small, defined regions. The success of the scientific method is best seen in such regions : " For everyday use, for scientific retail trade, the metaphysical categories still keep their value."[7] The dialectical approach to science has its value, on the contrary, in its comprehensiveness. The movements first seen by Hegel in the ideal world are, according to Marx and Engels, simply reflections of those in the objective world. Much of Engels' studies were devoted to exemplifying the Hegelian modes, particularly those of the transformation of quantity into quality, the interpenetration of opposites and the negation of negation, in the world of science. In *Anti-Dühring* this is done in the shortest way. But the *Dialectic and Nature* contains far more examples.

### *The Transformation of Quantity into Quality*

Philosophers still cavil at the use of the phrase " transformation of quantity into quality " on the grounds that it is not quantity that changes into quality, because quantity remains in the end. But the phrase is simply a shorthand way of referring to Hegel's law that purely quantitative changes turn into qualitative changes. It was in this form that Marx understood it, as shown explicitly in his letter to Engels (Letter 97). The examples which Engels gives, the case of ice turning into water,

[6]M.E.A., Vol. 2, pp. 150 et seq.
[7]M.E.A., Vol. 2, p. 189.



or water into steam, and that of the change of physical quality of a chemical substance with the number of atoms that are comprised in it, should have shown sufficiently clearly what this concept meant. With remarkable insight Engels says :—

> The so-called constants of physics are for the most part nothing but designations of the nodal points where quantitative addition or withdrawal of motion calls forth a qualitative change in the state of the body in question. (M.E.A., Vol. 2, p. 288.)

We are only now beginning to appreciate the essential justice of these remarks and the significance of such nodal points. The whole theory of quanta depends, like the theory of acoustic vibrations with which it has formal relations, on the distribution of nodes which mark out two qualitatively and quantatively different states of vibration.

The problem of qualities had always raised the greatest difficulties to the philosophers and furnished, as it still furnishes, a reason for invoking outside forces. From any logical materialist standpoint it is necessary to recognise that a new quality of a system is something not in any sense added to the system, but produced simply by a continuous change in its already existing components. To make this meaning perfectly clear, Engels cites as his final authority Napoleon.

> In conclusion we shall call one more witness for the transformation of quantity into quality, namely—Napoleon. He makes the following reference to the fights between the French cavalry, who were bad riders but disciplined, and the Mamelukes, who were undoubtedly the best horsemen of their time for single combat, but lacked discipline : " Two Mamelukes were undoubtedly more than a match for three Frenchmen ; 300 Frenchmen could generally beat 300 Mamelukes, and 1,000 Frenchmen invariably defeated 1,500 Mamelukes." (*Anti-Dühring*, p. 146.)

Engels found many examples in science of this transformation. Of these I can only quote one, that of Mendeleyeff's Periodic Law, which was to prove in the future so rich in further examples of the transformation of quantity into quality.

> Finally, Hegel's law holds not only for compound bodies, but for the chemical elements themselves. We know now that chemical properties of elements are a periodic function of their atomic weight and consequently their quality is determined by the quantity of their atomic weight (or, as we would now say, of their atomic number), and the proof of this has been made in a most striking way. . . . By the help of the—unknown—application of Hegel's law of the change of quantity into quality, Mendeleyeff has achieved a scientific feat which can well stand comparison with Leverrier's calculation of the orbit of the still unknown planet Neptune. . . . Perhaps those gentlemen who up till now have treated the transformation of quantity into quality as mysticism and incomprehensible transcendentalism will now explain that it is all perfectly self-evident, trivial, and platitudinous, that it has been long familiar to them and that we have nothing new to teach them. To have put forward for the first time a general law of nature and thought, in its

> most generally valid form, that will always remain as a historical achievement of the first order, and if these gentlemen for so many years have allowed quantity and quality to turn into each other without knowing what they were doing, they must console themselves with Molière's Monsieur Jourdain, who had all his life spoken prose unwittingly. (Engels' *Dialectic and Nature*, p. 289.)

Understood in this way, the concept of the transformation of quantity into quality can be, and is being, extremely valuable in scientific thought. We are learning more and more that specific qualitative properties of bodies depend on the *number* of certain of their internal components. If an atom can only link with *one* other atom, the result is a gas. If it can link with *two* or *three*, the result will be a solid of fibrous or platy character. If with *four*, a hard crystalline solid like diamond. If with *more than four*, a metal. Similarly the processes of freezing, boiling, vitrification, etc., depend on what are now known as " co-operative " phenomena. It takes a million or more molecules to make a substance which can be recognised as a solid or liquid : a smaller number leads to the qualitatively different colloid state.

### *The Interpenetration of Opposites*

The concept of the interpenetration of opposites has not been given by Engels the same coherent treatment as that of the others. Yet it recurs nearly all the way through his scientific writings. It appears in two shapes, firstly, as the Hegelian idea that nothing can be defined apart from its opposite, that, so to speak, everything implies its opposite (here Engels approached very close to the modern ideas of relativity) but also more objectively that there exist no hard and fast lines in nature.

> " Hard and fast lines " are incompatible with the theory of development. Even the border line between vertebrates and invertebrates is no longer unchanging. Every day the lines of demarcation between fish and amphibia, between birds and reptiles, tend more and more to vanish. Between the *Compsognatus* (a small dinosaur) and the *Archæopteryx* (a toothed bird of the same origin) only a few intermediary members are wanting, while toothed birds' beaks have been found in both hemispheres. (Quoted by V. L. Komarov in *Marxism and Modern Thought*, p. 199. See also M.E.A., Vol. 2, p. 189).

In physics Engels exemplified this principle by the example of magnetism, in which each N. Pole implies a S. Pole or vice-versa, or more generally in the balance between attraction and repulsion. Here, Engels' treatment is surprisingly modern. He understands forces not as mystical entities, but to be known only by the movements produced by them. This is characteristic of the modern tendency of turning mechanics into kinematics. In Engels' analysis attraction is simply the reflection of the coming together of bodies, as repulsion is of their separation. Thus heat in the kinetic theory of gases acts as a repulsive force.



### *The Negation of the Negation*

It is the same with the principle of the negation of the negation, which Engels illustrates with the famous examples of the barley seed negating itself into a plant and the plant further negating itself into many seeds, as well as the mathematical examples of the product of negative quantities and the differential calculus. These are the kind of statements that until recently made dialectical materialism seem quite unacceptable, indeed incomprehensible to scientists trained along official lines. Negation has always seemed to them something only applicable to human statements, but this is just a defect of language. If we had a word to describe how something in the course of its own inner development can produce something else different and in some sense opposite to it, and which comes in time to replace it entirely, that word would take the place of negation. Negation in this sense is not a symmetrical operation ; the negation of negation does not reproduce the original, but something now unlike both. As long as we deal in mere words, however, such statements can convey very little. It is in concrete examples that the significance of the negation of the negation can effectively be grasped. And if Hegel's and Engels' works had been treated on their merits instead of as something to be attacked in every possible way, the sense of their use of " negation of negation " would have been clearly apparent. But this, of course, would also have meant the recognition of the necessity of revolution, and that was far too uncomfortable to be accepted.

Just as the transformation of quantity to quality, so the principle of the negation of negation finds many examples in modern science. In almost every physical process in nature, there is a tendency for the process itself to create an opposition which ultimately brings it to a stop, which in turn results in the disappearance of the antagonistic process and the re-establishment of the original one. Take, for example, the case of the building up of mountain ranges due to strain in the earth's crust. This results in increased weathering which destroys the mountain range and accumulates sediments which lead to further crust strains, leading to further mountain building, etc. Modern physics is full of dialectical contradictions of this type—wave and particle, matter and energy—and even in Freudian psychology the provisional analyses of the mechanism of instinct and its repression are stated in a dialectical form. The whole of modern science is unconsciously affording more and more examples of the aspect of phenomena that can only be consciously grasped through dialectical materialism.

### *The Dialectical Process of Nature as a Whole*

But Engels did not confine himself to scientific illustrations of the validity of his philosophical position. His main task was a constructive one, and he gives in several places both in his Letters, in the *Anti-Dühring*, and the essay on Feuerbach, his general view of the dialectical process of nature taken as a whole. (See particularly Letter 232 and Chapters 5 to 8 of *Anti-Dühring*.) *Dialectic and Nature* was intended to give such a complete conception, but it was never finished and contains as it stands a number of more or less filled-in sketches of such conceptions.[8] In the omitted fragment from Feuerbach (p. 76 of the English edition) he recapitulates the chief points in which the science of his time had served to lay the basis of a comprehensible materialistic view of the development of the universe. In this he lays stress on three discoveries of decisive importance :

> The first was the proof of the transformation of energy obtained from the discovery of the mechanical equivalent of heat (by Robert Mayer, Joule and Colding). All the innumerable operative causes in nature, which until then had led a mysterious inexplicable existence as so-called "forces"—mechanical force, heat, radiation (light and radiant heat), electricity, magnetism, the force of chemical combination and dissociation —are now proved to be special forms, modes of existence of one and the same energy, *i.e.*, motion. . . . The unity of all motion in nature is no longer a philosophical assertion but a fact of natural science.
>
> The second—chronologically earlier—discovery was that of the organic cell by Schwann and Schleiden—of the cell as the unit, out of the multiplication and differentiation of which all organisms, except the very lowest, arise and develop. With this discovery, the investigation of the organic, living products of nature—comparative anatomy and physiology, as well as embryology—was for the first time put upon a firm foundation. The mystery was removed from the origin, growth and structure of organisms. The hitherto incomprehensible miracle resolved itself into a process taking place according to a law essentially identical for all multi-cellular organisms.
>
> But an essential gap still remained. If all multi-cellular organisms—plants as well as animals, including man—grow from a single cell according to the law of cell-division, whence, then, comes the infinite variety of these organisms? This question was answered by the third great discovery, the theory of evolution, which was first presented in connected form and substantiated by Darwin. . . . .
>
> With these three great discoveries, the main processes of nature are explained and traced back to natural causes. Only one thing remains to be done here: to explain the origin of life from inorganic nature. At the present stage of science, that means nothing else than the preparation of albuminous bodies from inorganic materials. Chemistry is approaching ever closer to this task. It is still a long way from it. But when we reflect that it was only in 1828 that the first organic body, urea, was prepared by Wöhler from inorganic materials and that innumerable so-called compounds are now artificially prepared without any organic substances, we shall not be inclined to bid chemistry halt before the production of albumen. Up to now, chemistry has been able to prepare any organic substance, the composition of which is accurately known. As soon as the composition of albuminous bodies shall have become known, it will be possible to proceed to the production of live albumen.

[8]M.E.A., Vol. 2, pp. 134, 153, 216.



> But that chemistry should achieve overnight what nature herself even under very favourable circumstances could succeed in doing on a few planets after millions of years—would be to demand a miracle.
>
> The materialist conception of nature, therefore, stands to-day on very different and firmer foundations than in the last century.

This quotation shows amply that not only had Engels a complete grasp of the essential stages of development up to the human level, but that he also saw very clearly the gaps in the explanation. The gaps are, first of all, the origin of the stellar universe as we know it, including the solar system and the earth, the origin of life on the earth, the origin of the human race, and the origin of civilisation. Each one of these questions was treated by Engels, and to each one he had valuable contributions to make.

### *The Origin of the Universe*

Once dialectical materialism is understood, the logical absurdity of all creationist theories of the universe become apparent. It is not that dialectical materialism provides an alternate theory, but it shows that you cannot treat the Universe in the same way that you treat any part of it, as something acted on from outside. Whatever moves the Universe must be the Universe. In so far as it develops it is self-creating. In particular, it shows the childishness of assuming a personal Creator whether with the honest anthropomorphism of early tribal peoples or the reactionary idealism of the mathematician Godmakers of the present day. As Engels wrote: "Gott=Nescio, 'aber ignorantia non est argumentum' (Spinoza)."[9] At the same time he saw very clearly that there were social and political reasons for maintaining such beliefs, and of emphasising the helplessness of man before the existing state of nature and, by implication, the existing social and political order.

As to the origin of the universe, Engels put forward no new theory, but implied that the key to its discovery would lie in the study of the nature of matter and movement. Engels was from the beginning attracted to the nebular hypothesis, and enthusiastically took up the observations of spiral nubulæ of which our galaxy is only one example.

### *The Origin of Life*

As the last quotation shows, Engels believed, at a time when that belief was far less plausible than it is now, in the chemical origin of life as a definite period in the earth's development. Short of a special creation of life, which had already become scientifically suspect by the middle of the 19th century, the only alternative theory was that life had always existed. This theory, upheld with the authority of Liebig and Helmholz,[10] Engels energetically combated. "Why should not," asked

[9]M.E.A., Vol. 2, p. 169. "God = I don't know, but ignorance is no argument."
[10]M.E.A., Vol. 2, pp. 176 et seq.

Liebig, " organised life be as old, as eternal, as matter itself ? Why should it not be as easy to imagine this as the eternity of carbon, and its compounds ? " To this Engels answered :

> (*a*) Is carbon simple ? If it is not, it is as such not eternal. (*b*) Carbon compounds are eternal only in the sense that under such and such conditions of mixture, temperature, pressure, etc., they can be reproduced. However, only the simplest carbon compounds, for example $CO^2$ and $CH^4$, can be eternal because they can be at all times and more or less in all places, produced and decomposed into their elements. (M.E.A., Vol. 2, p. 180.)

He argues that with these exceptions the conditions for the production of carbon compounds will not exist except on the earth in living beings or in the laboratory, and that though their eternal existence is thinkable, this merely shows that anything that is thought need not necessarily exist. Far stronger is the argument against the eternity of albumen, which can exist only under the very narrow limits of temperature and moisture of the earth.

> The atmospheres of astronomical bodies, particularly of nebulæ, were originally white hot—no place for albumen—so that space must be the big reservoir, a reservoir lacking air and nourishment and at a temperature which no albuminous body can possibly exist. . . . . What Helmholz says of the unsuccessfulness of experiment in making life is just childishness. Life is the mode of existence of albuminous substances : its intrinsic impetus comes from the continuous exchange of matter with the medium surrounding it, and with the ceasing of this exchange life itself ceases, and the albumen breaks up. (M.E.A., Vol. 2, p. 181.)

Time has not diminished the soundness of Engels' conclusions. We are still far from having analysed, much less synthesised, albuminous substances (for by that Engels did not mean protein in its modern sense as a pure crystalline chemical substance, but the complex of chemicals that underlie protoplasm—proteins, sugars, salts, etc. Nevertheless, through combination of modern biochemical knowledge with astrophysical and geological considerations about the early atmosphere of the planet, we can make a plausible picture of the origin of life by purely chemical means, and no other hypothesis for its origin can be put forward which will stand the slightest rational examination.

### *The Origin of Human Society*

The next gap which Engels recognised was that in the development of human society from the animal stage, but it was not sufficient on this point to see and appreciate at their true value the results of scientific workers : here Engels was a scientist on his own account. The prevalent popular view in the 19th century was still that of the special creation of man. The materialists, led by Darwin, Huxley and Haeckel, maintained that man was only a superior ape distinguished by a larger brain. This brain which gave man his peculiar character was just such a product



of evolution as a bat's wings or an elephant's trunk. Engels and Marx saw this crude explanation was hardly better than the theological one. They saw, long before anthropologists had taken up the question, that there was something qualitatively different about man which distinguished him from other animals, and that this was not an immortal soul, but the fact that man does not exist apart from society, and is in fact a product of the society which he has himself produced. Men, by entering into productive relations with each other, by the first exchange of food, and by the transmission of social characters through the family, became qualitatively different from other animals. These subjects were dealt with by Engels in an essay on " Work as the factor making for the transformation of Apes into Men," and in his most brilliant scientific work, *The History of the Family.*

V. L. Komarov, in his article on " Marx and Engels on Biology "[11] discusses at length this very point. The first stages, the development of man as a tool-using animal and as an animal capable of communicating with his fellows, can only be looked at from the biological point of view. It is at the same time the anatomical possibility inherent in a tree ape that has become a ground ape that make the use of instruments possible, and the use of instruments make the development of the human hand into its present form possible, without which it must have developed either hoofs or paws :

> So the hand is not only an organ of labour ; it is also its product. . . . . But the hand was not something self-sufficient : it was only one of the members of a complete and unusually complex organism, and what assisted the hand also assisted the whole body which the hand served, and assisted it in a double respect. (M.E.A., Vol. 2, p. 201.)

But at the same time, the development of manual skill inter-acted with the formation of primitive society.

> The development of labour necessarily assisted the closer drawing together of the members of the society since because of it instances of mutual support and of common action became more frequent and the advantage of this mutual activity became clear to each separate member. To put it shortly, men when formed, reached the point when they felt the need of saying something to one another. The need created the organ. The undeveloped tongue of the ape was slowly but steadily changed by means of gradually increased modulations and the organs of the mouth gradually learned to pronounce one distinct sound after another. (V. L. Komarov, *Marxism and Modern Thought*, p. 201).

### *The Origin of the Family*

In *The History of the Family* Engels takes up the story again at a later stage. It is here that the full value of Engels as a scientist can be appreciated. Long before its recognition by the official anthropologists,

[11] *Marxism and Modern Thought.*

he appreciated the significance of the matrilinear family group or clan that travellers and missionaries were showing to exist among all primitive peoples. With his wide historical learning he linked these facts with the history of early Greece and Rome, and showed first of all what an admirable economic unit the matrilinear family was at a certain primitive stage of production, and secondly how it broke down first to the patriarchal family, and finally to the modern small family, under the influence of the development of property, itself due to better methods of production. All the more recent work of anthropologists and historians has only served to confirm Engels' orginal ideas. The transformation from the matrilinear family to the present form has been traced also in China and can be seen in actual course of operation in all primitive societies in contact with European civilisation, as Malinowski in particular has shown in great detail. Engels' anthropological studies were not merely academic exercises: they were closely related to the great task that he shared with Marx, the transformation of capitalist into socialist society. In recognising the relatively happy, courteous, and upright life of savages compared to their civilised descendants, he conceives the task of socialism as that of the return, again through the negation of the negation, to the nobility of the savage, without the sacrifice of the material powers which capitalist development had presented to mankind. His historical studies, particularly *The History of the Mark*, all led to the effecting of this transformation. He realised its difficulty (Letter 227) :—

> History is about the most cruel of all goddesses, and she leads her triumphal car over heaps of corpses, not only in war, but also in "peaceful" economic development. And we men and women are unfortunately so stupid that we never can pluck up courage to a real progress unless urged to it by sufferings that seem almost out of proportion.

### *Engels' Work and the Development of Science*

What is the relation of Engels' work to the enormous development of science that has gone on since his time? What has already been said should be sufficient to show that this has only confirmed the value of his methods of approach and suggested their further application. For part of the intervening period this has been done by Lenin in *Materialism and Empirio-Criticism*, or by the writings of Plekhanov and Bukharin. At the moment this work is being carried forward both theoretically and practically by the younger Soviet scientists.[12]

There is no doubt that Engels would have recognised and welcomed the main advances in the scientific field which have occurred since his time. He would have recognised that four significant steps have been taken. The Relativity theory has finally dethroned the mechanical materialism of the Newtonian school, but only in its mechanical and not its materialist aspects. Engels, who welcomed the principle of the conversion of one form of energy into another, would equally have welcomed the principle of the transformation of matter into energy. Motion as the mode of existence of matter would here acquire its final proof. The second great advance, the whole modern atomic and quantum theory, would also appear to him as a vindication of dialectical materialism. The diverse qualities of the natural elements now find their explanation simply in the number of electrons which compose them. Even more clearly than in organic chemistry, the transformation of quantity into quality is exemplified. The great advances in bio-chemistry which show the phenomena of living animals and plants as functions of the properties of the chemical molecules which make them up is a direct exemplification of what Engels had written about the chemical basis of life. Finally, the discovery of the mechanism of inheritance through the chromosome theory (originally put forward by Mendel and now actually verifiable by microscopical observation) provides the material mode of transformation by which living animals develop and reproduce. These advances leave the main gaps in our knowledge still open, but we see more clearly than Engels could how they are likely to be filled. Nevertheless, Engels' work remains not only notable in its own time, but as valuable to us now in trying to keep the same all-embracing and historical approach to science that he possessed, and to use the methods he elaborated in pushing forward the solution of further problems.

After half a century of neglect, the methods of Engels and Marx are at last coming into their own in the scientific field. First, in the Soviet Union, but already also in England and France, the classics of dialectical materialism are being studied for the light they throw on present problems. In France in particular there have already appeared two notable contributions in *A la Lumière du Marxisme* (In the Light of Marxism) by a number of scientific writers and historians, and *Biologie et Marxisme* by Prenant. The crises of modern science appear in the first place as intellectual difficulties arising from new and apparently incompatible discoveries. The resolution of these crises, that is, the process of bringing them into harmony with the general movement of human thought and action, is a task for the Marxist scientists of to-day and to-morrow. The task is an endless one, and yet definite stages of advance can be established. We have through dialectical materialism a greater comprehension of whole processes, which before were only seen in their parts.

But it is not only in these general, almost philosophical, aspects of science that Engels' work is of value. In everyday work, those who take the trouble to follow Engels' hints find themselves more able to grasp the detailed connections of special investigations. The function of dialectical

[12] See for instance, *Science at the Cross-roads* (Kniga 1931); and *Science and Education in Soviet Russia*, by A. Pinkevitch (Gollancz); and *Marxism and Modern Thought*, already quoted.

materialism is not to take the place of scientific method, but to supplement it by giving indications of directions in which hopeful solutions may be looked for. As Uranovsky says in *Marxism and Modern Thought* :

> The dialectic of nature is a method of the investigation and understanding of nature. This conception of nature is founded on the application of materialist dialectic to the data of science as they are obtained at each given historical moment. The dialectic of nature brings no artificial connections into nature and does not solve problems by substituting itself for the natural sciences. It helps in critically understanding and connecting facts already obtained, it points out the paths of further investigation and fearlessly poses uninvestigated problems. (p. 153.)

It is for the scientific method to judge whether these solutions are or are not true.

By showing how science has grown up as it were unconsciously in relation to these productive forces, it shows at the same time how this unconscious purpose, once grasped, can be consciously directed. This is what is happening in the U.S.S.R., and, once fully in action, it will be found that science has reached a new plane in its development.

But that stage will not come of itself ; it will require intelligent collaboration on the part of the scientists themselves. In doing this they will make the memorial to Engels which is most in keeping with his spirit. For Engels was more than a scientist and a philosopher ; he was a revolutionary. With him science acquired a new and positive meaning. As the last thesis on Feuerbach has it :

"The philosophers have only interpreted the world in various ways. The point, however, is to change it."

*A Poet Finds Roots in Science*

Exact science and its practical movements are no checks on the greatest poet but always his encouragement and support. The outset and remembrance are there ... there the arms that lifted him first and brace him best ... there he returns after all his goings and comings. The sailor and traveler ... the anatomist chemist astronomer geologist phrenologist spiritualist mathematician historian and lexicographer are not poets, but they are the lawgivers of poets and their construction underlies the structure of every perfect poem. No matter what rises or is uttered they sent the seed of the conception of it ... of them and by them stand the visible proofs of souls ... always of their fatherstuff must be begotten the sinewy races of bards. If there shall be love and content between the father and the son and if the greatness of the son is the exuding of the greatness of the father there shall be love between the poet and the man of demonstrable science. In the beauty of poems are the tuft and final applause of science.

— Walt Whitman, *Leaves of Grass*. The first (1855) edition. Viking, New York 1959. Introduction, p. 14.



*a different perspective on*
*a great natural scientist*

## EINSTEIN AS PEACE ADVOCATE, POLITICAL ACTIVIST

*GDR astrophysicist*
*Hans Juergen Treder*
*is interviewed*
*by correspondent*
*Margrit Pittman*

*"There are few natural scientists who have had [their names connected] with a fundamental change of aspects of the scientific and philosophical perception of the world by mankind. Such scientists were Copernicus, Galileo, Newton, Darwin, and for our era it is Einstein." — Treder*

Albert Einstein, whose 100th birthday is being observed on March 14, was not, as some people refer to him, the father of the atom bomb, but a determined fighter for peace and especially for atomic disarmament, a vocal foe of the hydrogen bomb. His last public act before his death on April 18, 1955, was to sign a declaration by nine atomic scientists warning of the dangers of nuclear war. His signature was received by Bertrand Russell three days after the world heard the news of his death.

"Throughout his life Einstein was motivated by deep humanitarianism," Professor Hans Juergen Treder, the GDR's foremost astro-physicist and Einstein student, said. Professor Treder is director of the GDR's Central Institute for Astrophysics, a member of the GDR Academy of Sciences and vice-chairman of the Einstein Committee. In an exclusive interview with *World Magazine* Professor Treder traced Einstein's humanitarian development as well as the GDR's plans for four major scientific observances marking the anniversary. Others will be in Berne and Princeton, where Einstein also spent long periods of his life, as well as in Tel Aviv.

Einstein was appointed to Berlin's Humboldt University in 1914 and worked there until 1932, the years during which he made his most important scientific discoveries.

"Einstein had few political views when he came to Berlin except that he was strongly opposed to militarism," Professor Treder said. His opposition to militarism caused him to leave his native Ulm (Baden-Wuerttemberg) in 1895 and move to Switzerland, where he acquired citizenship in 1901. "He was one of the many spontaneous left-wing intellectuals who were greatly shocked by World War I."

His first important political action came in August 1915 when he was one of three initiators of a petition by intellectuals opposing German imperialist goals. During the war he supported many efforts to maintain international relations among scientists and become part of the "Federation for a New Fatherland," which united anti-war forces, from the conservative Walter Rathenau to the militant Social Democratic Deputy Karl Liebknecht.

When the revolutionary uprising at the end of World War I forced the Kaiser's abdication, Einstein expressed high hopes that bourgeois democracy would stimulate a "state of social justice."

These hopes were dashed and he was profoundly shaken by two events – the murders of Rosa Luxemburg and Karl Liebknecht in January 1919 and the Kapp putsch a year later. The Kapp putsch was an effort by the military to destroy even the meager gains of the revolutionary post-war movement and install a military dictatorship, an effort which caused bloody battles between workers and counter-revolutionaries.

These experiences, Professor Treder said, gave Einstein two important political insights manifest in his writings and activities. He gained the conviction that "the decisive role in every democratic development in Europe had to be played by the working class movement and that without support of the working class movement there was no future for bourgeois democracy."

The second realization was that a peace policy for Europe was only possible through recognition and cooperation with the new Russia. Einstein regarded "the revolutionary Russia as a great experiment to advance humanity," Professor Treder said. "While he was not particularly clear about revolutionary tactics, he was greatly impressed by the ethos of the revolution."

Einstein joined the Friends of the New Russia and became a member of its executive committee. By that time he had achieved world fame as a scientist and was invited to attend many international scientific conferences. While the government was glad that this served to enhance Germany's prestige, it was at the same time profoundly uneasy, and confidential reports from embassies and secret services – carefully preserved in Gestapo files – show that Einstein was closely watched wherever he went.

During the early 1920s Einstein had developed a deep interest in the radical pacifists. He shared their belief that if only a sufficient number of recruits could be persuaded to refuse military service, wars could be prevented. "This was not what the officials were concerned about," Professor Treder said. "Their worry was about his role in the Friends of the New Russia, as we know from the files." He added: "Einstein would most certainly have no chance of getting a public service job in the FRG today," referring to the practice of Berufsverbote, as the black-listing of public service employees with progressive views is called. In his youth Einstein had held such a job for several years in a Swiss patent office.

"Einstein's pacifism was always linked with a profound anti-imperialism," Professor Treder said. "In my opinion this also explains his involvement with zionism. He was deeply concerned with the rising anti-Semitism in Hungary under the Horthy regime and in Poland, as well as the persecution of Jews under czarism. He considered that a Jewish settlement in Palestine would offer these people a refuge. But he felt this idea only feasible by fully cooperating with the Palestinian population. Lack of such cooperation, he felt, would only strengthen British imperialism. He did have the idea that funds and technical know-how contributed by Jews throughout the world for such a venture would help raise the living standard of Jews and Arabs alike."

Professor Treder said that Einstein always showed great concern with the fate of Jews and did much to help those suffering from persecution. His interest in the state of Israel must be regarded primarily as an effort to further the social and cultural concerns of Jews. When Einstein was offered the presidency of Israel after Chaim Weizmann's death in 1952, he refused for reasons of age, but "this type of representation job was contrary to everything Einstein wanted." Professor Treder thinks one can say that Einstein's interest in Israel sprung from a humanitarian commitment and did not imply agreement with the political development as it unfolded.

In the early 1930s, with the growing threat of Hitlerism, Einstein's political views entered a new phase. He began to realize that only the united action of all workingclass parties could prevent fascism. At that time Einstein lectured at the Marxist Workers' School in Berlin.

During his last stay in Berlin in the summer of 1932, Einstein was among those who recognized that the only hope for preventing a Nazi dictatorship was the united action of the two great workers' parties and the trade unions. Together with artist Kaethe Kollwitz and author Heinrich Mann he wrote an open letter to the chairmen of these groups. Ernst Thaelmann, Otto Wels and Theodor Leipert, calling for a common slate of candidates of the two workers parties. The letter referred to "the clear desire of the workers to stand together – a step which is also of vital importance to the rest of the population."

Right after Hitler took power, Professor Treder said, Einstein realized that it was necessary to take up arms against fascism. This position caused his exclusion from several pacifist organizations.

This attitude also led him to head a group of scientists who wrote to U.S. President Franklin Delano Roosevelt in 1939 warning him of the efforts of the Hitler regime to develop atomic weapons.

Once the fascists had been defeated, Einstein repeatedly called for "a new type of thinking" which would eliminate the danger of atomic War. He expressed anger at the use of the atomic bomb in Hiroshima and Nagasaki and accused the Truman government of making no serious attempts to "come to a basic agreement with the Soviet Union."

He participated in an Emergency Committee of Atomic Scientists in 1946 and repeatedly emphasized the need for a foreign policy of all states geared to make nuclear war impossible. This concern also prompted him to become one of the initiators of the Pugwash conference, an effort to create understanding among scientists throughout the world. Until his death he showed great concern for the realization of peaceful coexistence of all nations ...

– *World Magazine* 1 March 1979

## PYOTR FEDOSEYEV ON SOCIO-BIOLOGY

[In socio-biological theories] we have an obvious attempt to synthesize and converge biological and sociological researches, an attempt which, despite all reservations, ignores the specific social laws that determine social phenomena... In essence, there is taking place, under the flag of convergence, a substitution of biology for sociology. Such attempts are not grounded in science and are not in accord with the fundamental principles of the scientific method which calls for concrete research into each specific area of phenomena...

Despite all their interdependence, the biological and the social are different spheres of being, in [each of] which specific law-governed patterns operate... we must find, in reality itself, the real and concrete *mode of interaction* between these two spheres under which, first, they will not be identified with each other, and, second, will not be divorced from each other. In other words, the specificity of each of these two spheres of being has to be revealed as well as the continuity, interconnection and mutual transitions between them. This should be done in respect of all aspects of the variegated and composite problem of the biological and the social. The reference is, first and foremost, to the instance of a blend of the biological and the social operating in one proportion or another in certain facts of human behaviour.

Marxism emphatically rejects any biologisation of social phenomena because it is the social law-governed patterns that fully determine the "behaviour" of classes, nations and all social groups in general. This, however, does not rule out the need to study the relation between the biological and the social in *man as an individual.* In this case, too, there can be no return to any forms of social-Darwinism, or any kind of biologism in general. It is the ABC to us that man is a creation of society, that he is a social being, that social conditions determine his development and behaviour, and so on. But we are also opposed to the over-simplified ideas that there are no natural determinants in man's existence. Man is a social creature, but at the same time he is also a part of nature, a biological creature...

The human organism is born, takes shape and develops in keeping with the socially mediated laws of biology. The mediation of the biological through the social is effected, in the main, through the central nervous system, which performs, on the one hand, the function of reflecting the surrounding world in the form of representations, notions, and judgments and, on the other hand, the function of unifying, regulating and coordinating processes within the organism in its interaction with the external and, first and foremost, the social environment. The mechanism and structure of the interaction between the social and the biological are cognized through the methods and means of various sciences, each of which deals with some particular aspect of the problem.



Present-day science faces a most complex task, that of revealing, with due account of all this variety of aspects, the concrete and overall *mode* or *"mechanism"* of the interaction between the biological and the social and do that in such a way that will ensure (1) the specificity, the non-identity of these two spheres of being in man's development and behaviour, and (2) the continuity of and interconnection between these spheres.

Marx defined this fundamental type of interaction between the biological and the social as follows: while changing external nature in the process of labour, man at the same time changes his nature [*Capital,* vol 1, ch 7, Sec. 1]. In other words, man's *nature* is itself a product of *history.* This classical proposition of Marx is incompatible, in principle, with all and any varieties of the dualist interpretation of the relation between the biological and the social in man. In this terse but meaningful formulation, Marx revealed the real dialectical interlink between these two spheres of being. In the course of his social activities, man *changes* but does not cancel or destroy within himself what is natural and biological. In consequence of this, the continuity between the biological and the social, and their interlinks, do not disappear, but develop historically. Genuine unity, but not identity, of the two exists primarily in people's *labour*, i.e., their essentially social activity...

The Marxist thesis that man's nature is a product of history constitutes the only possible philosophical basis for the elimination of the two above-mentioned erroneous extremes (the biologistic and the sociologistic) in the study of the problem of the biological and the social. On the one hand, the ultra-sociological and socio-logistic assertion that man is merely a concentrate of the economy or the socium and is completely devoid of everything biological, organic, or natural in general--that assertion cannot stand up to criticism. On the other hand, one cannot but strongly reject the directly opposite biologistic assertion made by Freud, Lorenz and others that *animal* urges and instincts underlie *man's* behaviour (in particular, his "aggressiveness"). In fact, according to Marx, as well as the evidence of present-day science, the natural in man, of course, in some measure determines man's behaviour, which depends, in particular, on his temperament, natural abilities and possibilities. This natural element in man does not disappear in the course of history, but is substantially modified and developed, adopting a qualitatively different form in the process of mankind's anthropogenesis and entire subsequent social progress. Consequently, historically fashioned human needs cannot be reduced to those of animals...

The very notion of "environment" has not only the sociological but also the purely biological aspect. Consequently, if any particular study places emphasis on the role of the environment in man's development, that does not mean that such a study is sociologistic in greater measure than it is biologistic, inasmuch as the environment can be understood both in the sociological and the purely biological sense, and also as a sum of physical conditions...

– *Social Sciences* (Moscow) 9 (3): 20-43, 1978)

## On Human Nature, by Edward O. Wilson
## Harvard University Press 1978

Reviewed by Ethel Tobach (comparative psychology)
American Museum of Natural History

### MECHANICAL MATERIALISM REVISITED

Although planned as the third in the trilogy, beginning with *Insect Societies* and *Sociobiology*, in this book Wilson seems to have been affected by the critics of the second book *Sociobiology*. This is evident in his imprecise labelling and grouping of his critics as "learning theorists," "Marxists" and "ultraenvironmentalists." He presents his vulgarized version of their "positions" without giving any bibliographic references to support his attributions to them. He also apparently is responding to those who have criticized him from a viewpoint based on the concept of levels of organization and integration by offering a bowdlerized concept in his proposal of sociobiology as the anti-discipline to other disciplines. The most outstanding target of his response to criticism, however, is "Marxism."

> Marxism and other secular religions offer little more than promise of material welfare and a legislated escape from the consequences of human nature (p 3)... It is a misconception among many of the more traditional Marxists... that social behavior can be shaped into virtually any form (p 18)... Thus, institutionalized Soviet Marxism, which is itself a form of religion embellished with handsome trappings, has failed to displace what many Russians for centuries have considered the soul of their national existence [that is, the various forms of organized religion, ET] (p 70)... most of contemporary intellectual and political strife is due to the conflict between three great mythologies: Marxism, traditional religion, and scientific materialism. Marxism is still regarded by purists as a form of scientific materialism, but it is not. The perception of history as an inevitable class struggle... is supposed to be based on an understanding... of pure economic processes... Marx, Engels, and all the disciples and deviationists after them, however sophisticated, have operated on a set of larger hidden premises about the deeper desires of human beings and the extent to which human behavior can be molded by social environments...

To replace the "failures of 'Marxist' materialism" he offers "scientific materialism." His definition of scientific materialism derives from his concept of science. "Science may be regarded as a minimal problem consisting of the completest presentation of facts with the least possible expenditure of thought," He cites this definition by Ernst Mach (p 11). But Wilson is not satisfied with the definition, and adds the "other half of the scientific process... The remainder consists of the reconstruction of complexity by an expanding synthesis under the control of laws newly demonstrated by analysis... When the observer shifts his attention from one level of organization to the next, as from physics to chemistry or from chemistry to biology, he expects to find obedience to all the laws of the levels below. But to reconstitute the upper levels of organization requires specifying the arrangement of the lower units and this in turn generates richness and the basis of new, unexpected principles" (p 11).



According to Wilson, one of the pinnacles of social organization reached in evolution is that of insect societies (wasps, bees, ants). They are successful because they are made up of individuals which are related ("sisters") and thus genetically very similar. Therefore, they "cooperate" with each other because they are guaranteeing that their genes will be passed on to the next generation. This is an untested formulation devised by Wilson which he defends by analogy and description. (Experimentally testable explanations of this form of social organization have been offered by others, e.g., Schneirla, Topoff). As an example of his concept of levels of organization, he makes the following set of statements: Societies of wasps, bees and ants dominate and alter most of the land habitats of the earth. In Brazil, they constitute more than 20 percent of the weight of all land animals, including worms, toucans and jaguars.

Wilson equates species success and domination with number and weight; he says this is due to their genes; therefore, species success is due to genes. Further, the "lower" level of genetic process yields the emergence of a new form of social organization which in turn yields a richness of new principles ... by rearranging the elemental unit, the chromosomes or genes. If they are rearranged otherwise, the social organization is different.

The mixture of static, structural, non-dialectical levels is an example of his "new" materialism, "scientific materialism." Wilson's interpretation of the concept of levels is reductionistic and mechanical. A truly scientific application of dialectical materialism to the relation between genes and social organization recognizes an extremely complex and indirect relationship even in the case of insects to say nothing of human beings. The biochemical processes which are expressed by different relationships of chromosomes and genes have profound implications for the next, qualitatively different level of organization, that is, the elaboration of enzymes and other molecular arrangements of materials which yield qualitatively different series of levels, hierarchically arrangeable, such as cells, tissues, organs and systems (e.g. respiratory, endocrine, nervous).

These levels and their *integration* (resolution of their contradictions) are expressed in different stages of development, *in particular environmental contexts. (Environmental = "social action" as defined by James M. Lawler in I.Q., Heritability and Racism,* N.Y., International, 1978). On the "micro" level of the individual organism in its social environment and on the "macro" level of the social group in its particular physical setting, changes take place which are more or less adequate to affect the function and activity of the individual organizam and affect the social relationships of the group. It is the history of these changing relationships which brings about the characteristic social organization and behavior of any group of animals. The wasps, bees and ants stand in a particular contradictory relationship with their environment; because of the inner contradictions of their own levels of integration, they are not likely to be so successful in the control of their environments as are the higher animals, such as primates and humans.

Wilson's "scientific" materialism is a variation of mechanical materialism. Engels, writing on Feuerbach, described mechanical materialism as follows:

> "Nature, it was known, was in constant motion. But according to the ideas of that time, this motion turned eternally in a circle and therefore never moved from the spot; it produced the same results over and over again."

That Wilson is caught in this circle becomes particularly obvious when he turns from insects to humans. Because, for him, the nature of humans is "biologically" determined, "we are forced to choose among the elements of human nature by reference to value systems which these same elements (i.e., the genes—ET) created in an evolutionary age now long vanished" (p 196). In other words, since human genes are "the same" the value systems they produced when they first started to function are "the same." Nature and evolution may keep changing, but for Wilson, nothing changes, except by accident.

While Wilson disingenuously admits that his own view "is mythology in the sense that the laws it adduces here and now are believed but can never be definitely proved to form a cause and effect continuum from physics to the social sciences," he nevertheless asserts that we have come to the crucial stage in the history of biology when religion itself is subject to the explanation of the natural sciences... sociobiology can account for the very origin of mythology by the principle of natural selection acting on the genetically evolving material structures of the human brain" (p 192). The structure that provides the material base for the human need to believe in the myth is the hypothalamic-limbic complex, the neural system where "gut" feelings of right and wrong, of morality, ethics and philosophy have evolved. Further, "scientific materialism embodied in biology will, through a reexamination of the mind and the foundations of social behavior, serve as a kind of anti-discipline to the humanities... In order to address the central issues of the humanities, including ideology and religious belief, science itself must become more sophisticated and in part specially crafted to deal with the peculiar features of human biology" (p 204).

And what is the special craft that science must develop? The task before science is based on Wilson's fundamental belief in genetic determinism: social behavior is ultimately derived from a genetic code.

> Human genetics is now growing quickly along with all other branches of science. In time, much knowledge concerning the genetic foundation of social behavior will accumulate, and techniques may become available for altering gene complexes by molecular engineering and rapid selection through cloning... The human species can change its own nature. What will it choose? Will it remain the same, teetering on a jerrybuilt foundation of partly obsolete Ice-Age adaptations? Or will it press on toward still higher intelligence and creativity?... New patterns of sociality could be installed in bits and pieces (i.e., recombinant DNA types of operations, ET). It might be possible to imitate genetically the more nearly perfect nuclear family of the white-handed gibbon or the harmonious sisterhoods of the honeybees (p 208).



Although he skates on the thin ice of a regressive eugenics based on an equally regressive Social Darwinism, Wilson is astute enough to recognize the dangers. He, therefore, sets up the following dilemmas which scientists and society must face. The first dilemma is that human beings have no place to go. The species lacks any goal external to its own biological nature (p 195). In other words, once it has solved all its problems, there would be no further purpose in life. The second dilemma is that to change human nature, which because of its biological nature, has no place to go, and thus give it a place to go, genetic engineering is required (eugenics). But, because evolution favors diversity in the genetic pool (i.e., distribution of many different variations of the characteristics of individuals belonging to the same species). Wilson is willing to concede that human beings are faced with the third dilemma. "... the preservation of the entire gene pool as a contingent primary value [is necessary—ET] until such time as an almost unimaginable greater knowledge of human heredity provides us with the option of a democratically contrived eugenics" (p 198). In other words, because we do not know which genes are the "desirable" ones, we have to preserve all the genes. But, as the goal is to work out the genetic basis of social behavior, one supposes that it is a matter of time for those genes which will be found "undesirable." This is the third dilemma: it may be that there is something in the human genetic make-up which will prevent the species from pursuing this genetic knowledge and implementing it.

In a letter to Engels in 1862, Marx writes: "It is remarkable that Darwin recognizes among brutes and plants his English society with its division of labor, competition, opening up of new markets, 'inventions' and Malthusian 'struggle for existence.' It is Hobbes' *bellum omnium contra omnes*, and it is reminiscent of Hegel in the *Phenomenology*, where bourgeois society figures as a 'spiritual animal kingdom,' while with Darwin the animal kingdom figures as bourgeois society." Wilson reflects his world in his theory also, a world in which women and minorities in capitalist and other societies hold their positions because of the genetic evolution of their form and physiology. Even undeniable social changes which have taken place are attributed to biology. According to him, the reason slavery did not succeed as a system for human beings as it does for some species of insects is that human beings evolved a "... hard, irreducible, stubborn core of biological urgency, and biological necessity, and biological reason, that culture cannot reach and that reserves the right, which sooner or later it will exercise, to judge the culture and resist and revise it." (Lionel Trilling: *Beyond Culture*, cited by Wilson on p. 80). Slavery is defeated, not because of social consciousness derived from changing social relationships, but because of human "biology."

Wilson really believes that "... the core of social theory... is the deep structure of human nature, an essentially biological phenomenon that is also the primary focus of the humanities" (p 10). It follows that society cannot be fundamentally altered except by genetic engineering, the correct implementations of which may never take place because humans may be genetically programmed not to do this. In the best of cases, it would have to be delayed until there is an "unimaginable" development of science. I think that people will not wait that long for genetic engineering to improve itself that much. —*Benjamin Rush Newsletter,* March 1979. □

*Whither Science Under Socialism?*

### Philosophy of Optimism, by B. G. Kusnetsov
### Progress, Moscow 1977

*Reviewed by Hyman R. Cohen, Brooklyn, N. Y.*

"Where is science headed?" is a question which usually receives ambiguous answers from scientists and philosophers in the West, where pessimism is endemic not only because of the nature of capitalist society but also from general lack of a consistent, embracing philosophical framework within which and by which the development of science can be examined. In sharp contrast, Kusnetsov offers here an optimistic answer that envisages a better, more satisfactory world based on his predictions of how science will unfold in the near future, developing symbiotically with the institutions of socialist society. His optimism is based on very material considerations:

1) He links the epistemology of dialectical materialism to the development of non-classical science: because the world is knowable, science will successfully probe deeper and deeper into the fundamental nature of matter and energy, especially in the areas of atomic power, quantum electronics and molecular biology. Incidentally, not all of this new knowledge and know-how is expected to arise within socialist society.
2) The new goals—material and humanist—will require the upward transformation of the present industrial base by human labor and, in the process, labor itself will be transformed through absorbing the new science and technology. Scientists themselves will be transformed along with the content of the knowledge generated. By the year 2000, it is predicted, the accelerating rate of technical-industrial development will guarantee a continued upward development of society.
3) This optimistic program can be accomplished only in an established socialist society because only such a planned society is capable of solving the tough economic and social problems as they arise, making the required decisions on the basis of the constantly developing science and technology. In this process, society's needs provide the main determinant of the way science itself develops.

Kusnetsov thus, as physicist, philosopher and even economist, presents quite a challenge to the reader. Careful attention is required to follow his penetrating study of how science operates in an unfolding socialism, guided by a scientific philosophy. But the reward is a stimulating experience for either critic or partisan of dialectical materialism. His enthusiasm is contagious. □



## BIBLIOGRAPHIC NOTES FOR NATURAL SCIENTISTS

*Annotation is by the editor except as noted.*
**Asterisk designates item from a socialist country available through Imported Publications Inc., 320 W. Ohio St., Chicago, Ill. 60610.*

### A USEFUL PERIODICAL

*AIMS Newsletter*, published bi-monthly by American Institute for Marxist Studies, 20 East 30th St., New York, NY 10016. Yearly subscription: domestic $6.00; foreign $7.00

Notes upcoming conferences and symposia on Marxist topics. Provides a wide-ranging reference list of current books and journal articles related to just about every aspect of Marxism.

### GENERAL REFERENCES

Afanasyev, V. et al., 1979. Systems Theory: Topical Aspects. *Social Sciences* (Moscow) 10 (1), 29-110, subscription $7.50/year.*

Five collected articles in this issue deal with the systems approach in social cognition (Academician Afanasyev), in Marx's methodology (V. Kuzmin), in wholeness concepts (I. Blauberg), in global socio-economic modeling (N. Lapin) and in the methodology of science (V. Sadovsky).

Colman, Morris, 1978. *On Consciousness, Language, and Cognition: Three Studies in Materialism.* American Institute for Marxist Studies, 20 East 30th St., New York, NY 10016. Paper $1.50

In his study of consciousness, Colman makes an original and valuable contribution by establishing a materialist basis in the individual's *experience* for the development of self-awareness and volition. [See excerpt, page 68.] The discussion of language provides a useful look at Pavlov's ideas. The final section, on Reflection and Ideology, is weakened by a mechanistic tendency to identify absolute truth with successful practice in the technological sense, and by what seems to be a misreading of Lenin's use of the term "absolute." Overall, Colman is highly worth study.

Fay, Margaret, 1978. Did Marx Offer to Dedicate *Capital* to Darwin? *Journal of the History of Ideas* 39, 133-146.

The answer is "no" and the proof seems full. [*AIMS Newsletter, May 1978*].

Forman, Paul, 1969. Weimar Culture, Causality, and Quantum Theory, 1918-1927: Adaptation by German Physicists to a Hostile Intellectual Environment. *Historical Studies in the Physical Sciences* 1, 1-115.

While Nazi thugs attacked the German working class with physical weapons, more subtle methods were employed to condition the academic world for its role in Third Reich imperialism. Though Forman's scholarly paper does not show the political connection, it details with precision the historical process by which a decadent external ideology was imposed on phycisists and physics. Whether consciously or not, the study seems entirely consistent with historical materialism. There is material for a Brechtian drama in this required reading for those interested in the philosophical problems posed by quantum mechanics.

Goldstick, Dan, 1977. Reading Althusser. *Revolutionary World* 23, 110-132.

A thoughtful critique of the "Althusserian bent for making really complicated matters over-simple" and vice-versa. The doctrines and concepts of Engels are contrasted with those of Althusser, revealing especially the latter's tendency to confuse relative truth with empiricism.

Goldstick, Dan, and Frank Cunningham, 1978. Activism and Scientism in the Interpretation of Karl Marx's First and Third Theses on Feuerbach. *Philosophical Forum* 8, 269-287.

Deals with the interaction of sensuous human activity and thought objects or concepts, putting the famed theses in their proper historical setting, as Marx and Engels emerge from the Young Hegelian stage of their development. An effective contribution to the ongoing defense of Marxism against contemporary Western "Marxologists."

Gruner, Rolf, 1977. *Theory and Power: On the Character of Modern Science.* Humanities Press, Atlantic Highlands, N.J.

Gruner states his central concept thus: "There exists such a thing as modern science because the aim and urge of modern man is power, because, in other words he is driven by the desire to be capable of effecting changes in the world as he pleases" [p. 53]. This approach leads to an unwarranted overemphasis on a particular aspect of the subjective side of the scientific process while ignoring the complexity of the social and economic forces at play in today's institutionalized science. Nevertheless, much that is valid will also be found in his exposition of the historical development and character of modern science, e.g., the discussion of the relation between science and technology. [Hyman R. Cohen.]

Lawler, James M. 1978. *IQ, Heritability and Racism.* International, New York. Paper $3.95.

"Regarding the longstanding debate about heredity versus environment, [Lawler] draws upon the Marxist concept of consciousness as being always 'conscious activity.' Biology and environment are a *unity*, a developing historical unity, the *unity* of opposites, not one aspect as against the other." [Irving J. Crain, *Political Affairs*, Feb. 1979. Emphasis in original.]

This book is also a tremendous example of the way Marxist philosophy can heighten scientific consciousness. Focusing on the oppressive role of the IQ concept in the public school, Lawler skillfully reveals the unscientific nature of the concept and its development as an instrument of class domination—from the paternalistic pragmatism of Binet to the vicious biologizing of Jensen.



Recommended to all scientists as an example of applied dialectical materialism.

Marquit, Erwin, 1978. Philosophy of Physics in General Physics Courses. *American Journal of Physics* 46 (8): 784-89.

Marquit performs a valuable service to science educators in exposing here the latent and often questionable biases present in many current physics textbooks. The well-known text *Fundamentals of Physics* by Halliday and Resnick is criticized for its logical positivist approach and its adherence to the operational viewpoint which implies that the real nature of the material world is revealed in those quantities amenable to measurement and the interrelationships between those quantities. The contrary view of dialectical materialism which asserts the primacy of matter, the universality of change and the dialectical nature of processes giving rise to change is briefly discussed and used as a basis for criticism (not all adverse) of other well-known physics texts. Suggestions are made on the manner of presenting key concepts to physics students in order to counter the impression that physics is only concerned with relationships between quantities that can be operationally defined. [Stanley Jeffers.]

Marquit, Erwin, 1977. Statistical Processes and Causality. *Revolutionary World* vol 23/25 pp 171-179.

Marquit addresses the question: "Is it reasonable to conclude that, owing to the dialectical interconnection of chance and necessity, a phenomenon characterized by statistical processes on one level of organization of matter will turn out to be a consequence of simple causality on an underlying level?" His answer is a surprising "no", explicitly rejecting David Bohm's Marxist analysis as not "appropriate." Though Marquit advances dialectical categories to support the concept of a cause-effect bond that is "statistical" because of the inner nature of matter," his conclusion appears essentially the same as that of Poincaré in 1904: "Facts which appear simple to us will be only the result of a very large number of elementary facts which *the law of chance alone* will lead to a single goal." [Quoted by Max Jammer in *The Conceptual Development of Quantum Mechanics*, McGraw-Hill 1966 p. 170, emphasis added. Jammer reviews origins of statistical-causality concept on pages 166-171.] The greatest practical and theoretical objection to the idea of statistical causality is that it discourages further search along the materialist path suggested by Einstein who, at age 67, remained "firmly convinced that the essentially statistical character of contemporary quantum theory is solely to be ascribed to the fact that this [theory] operates with an incomplete description of physical systems." [*Albert Einstein: Philosopher-Scientist* P. S. Schilpp, ed. New York 1951, p. 666.]

Mikulinsky, Semyon, 1977. History of Natural Science as a Science: Present State and Theoretical Problems. *Soviet Studies in the History of Science.* Problems of the Contemporary World, No. 53, pp. 8-31. Moscow.*

The author insists that materialism as well as dialectics be applied in the historiography of science. As a rule, he says, new scientific theories originate from the clash of old theories and new facts (not simply the choice between two existing theories as proposed by Thomas Kuhn). Also rejected is the mechanistic view of a rigid external social control over the development of science: history of science should integrate the internalist and externalist factors.

Weiss, Donald D., 1977. The Philosophy of Engels Vindicated. *Monthly Review*, 28, 15-30.

A well-argued defense not just of Engels but also of the materiality of culture as the basis for historical materialism.

## BOOKS RECEIVED

Fox, John and William Johnston, 1978. *Understanding Capital: A Guide to Volume 1.* Progress Books, 71 Bathurst St., Toronto, Canada M5V 2P6. Paper $3.95.

Wald, Henri, 1975. *Introduction to Dialectical Logic.* Humanities Press.

### *The Ontogeny of Consciousness*

Consciousness is the necessary response to the new — to every event impinging on the nervous system for which there is no ready established response. Thought is a conscious response to a new perception, whether of an inner event or an external one. Consciousness is the mode in which new responses are generated and guided, the subjective reaction to any event that contains any novelty whatever.

It must follow that unconscious reactions (more frequent than conscious ones in everyday human living) are not the responses of non-knowledge. On the contrary, a response can be an unconscious one only if it is an entirely familiar or inborn response to a familiar situation, presenting no newness for which consciousness would be needed. It is a "dynamic stereotype" (in Pavlov's phrase) in a situation so accepted that it is "taken for granted." Any change or novelty in an otherwise familiar pattern of events instantly calls up the processes of consciousness to deal with it. Unconscious activity is thus seen to play an opposite role to the romantic one assigned to it in Freudian speculation. That which is unconscious, far from being the unknown, is that which is so familiar that to question it is "unthinkable" ...

The actual scope of consciousness in each new situation is determined by the individual's own prior history, and is therefore zero at birth ... Consciousness in the infant develops slowly. No response (consciousness being a particular form of response) can be more comprehensive or precise than the scope of the individual's own learning at any age ...

In perception or simple consciousness the old does not appear in its own form (as it does partially in recall). The many traces of the old take a form that directly conditions the perception of the new ... The old is not consciously present precisely because it reflects prior experience that is no longer new or unknown. The perception is an integration of the new sensory qualities of completed prior experience. The perception is neither the one nor the other, but a new integration of both; being new and more inclusive than either, it must be conscious.

— Morris Colman, *On Consciousness, Language and Cognition.* (See Page 65).



# SCIENCE AND THE SUPERSTRUCTURE

**Comment on distortions of science that reflect the economic, political and ideological influences of our social structure.**

## Nuclear Safety as Seen by *Science*

On 26 January 1979, while the Union of Concerned Scientists was warning that Three Mile Island should be shut down, readers of *Science* were treated to an editorial which lamented the influence of the democratic process over nuclear safety decisions:

> Society is becoming increasingly well informed and anxiety-prone about technology-associated risks, which leads to desire for their elimination. The logical and traditional approach is first to estimate the risk, a scientific task. Then comes the issue of risk acceptance, a most difficult step—moving from the world of facts to the world of values. Ideally, judgments involving risk acceptance should be made on society's behalf by a constitutionally appropriate body. But no such public decision-making process exists. We make do with disparate efforts of individuals, special interest groups, self-appointed public interest groups, and legislative, judicial and regulatory systems.—— *Cyril L. Comar, Professor Emeritus, Cornell University, and Director, Environmental Assessment Department, Electric Power Research Institute, Palo Alto, California 94303.*

Then, 11 May '79, came editorial regrets that scientists tend to be "defensive" over the "distressing events" of Three Mile Island, implying that even the scientific process itself is no longer to be trusted:

> A passing acquaintance with the nuclear safety position of various organizations supported by capable scientists, attendance at a nuclear-licensing hearing, or a day of eavesdropping in the corridors of several well-known government, academic, and consulting scientific organizations would show that scientists are, on this matter, no less influenced by personal feuds and ideological differences than the small-town clergy of a Trollope novel is on matters of ceremony and doctrine. I would go so far as to say that the divisions are deeper and more bitter among the scientific literate than in the general public.
>
> The paradox—that the best informed are the most confused—disappears only if we consider the whole nuclear power issue as merely symbolic of a deeper ideological rift, comparable to, say, the early 19th-century Romantic revolt... If, as I am suggesting here, the nuclear safety issue is more of a quasi-religious than a technological conflict, then widespread improvement of scientific literacy is unlikely to improve matters.—— *Richard L. Meehan, President, Earth Science Associates, Palo Alto, California 94304.*

Editorialist Meehan neglected to mention that economic interest (direct and indirect) and class orientation (conscious and unconscious) are important elements in the matrix that has generated the highly polarized versions of scientific "truth" which he deplores (e.g., the Union of Concerned Scientists versus the Rasmussen Report). It is striking to note that there is no more difference in the postal zip codes of these two authors than there is in the social origins of their ideas. Both editorials express deep distrust of the democratic process and the ability of people to act intelligently (when information is not purposefully withheld or distorted).

## Unmentionables in the Science "Community"

The 1978 Lasker Award for Basic Medical Research went to three men, ignoring the woman who had been first author on the first reports of their pioneering investigations in the opiate receptor and peptide area. Previously, the National Institute of Drug Abuse gave its 1977 Pacesetter Research Award to six men who had NIDA support for these studies, also ignoring the woman. After the scandal came to light, NIDA spokesman William Pollin wrote to *Science* (6 April 1979 p. 8) as follows:

> In retrospect, we feel that it was a significant omission on our part that Dr. Candace Pert was not included. Her graduate role was the issue at the time; subsequent increased awareness of her major contribution has led us to this revised conclusion. Selecting recipients for prestigious awards is a complex social process in which "scientific merit," unfortunately, is often only one of many considerations. Sometimes, serious mistakes are made.

Why could not the NIDA administration bring itself to mention the evident role of sexism in that "complex social process" which also and admittedly discriminated against Pert as a student? Was it out of consideration for the feelings of men who had made no effort to share the honor with their woman colleague? We join with the authors of a letter to *Science News* (12 May 1979) in asking: *"Where is it written that mistakes cannot be rectified?* [Emphasis in original.] Why cannot the Lasker jury reconvene and redo its work? Why cannot the NIDA group do likewise? Why should Pert suffer from having been passed over twice for awards in which... she justly deserved to share?"

## Is There a Spook in Your Lab?

In 1955 the CIA set up and financed (90%) a *Human Ecology Society* under Cornell professor Dr. Harry Wulff, later president of the American Neurological Association. Until it folded in the mid-60s, the "society" funneled grants to university scientists for research aimed at achieving control over the human mind. Most recipients were reportedly unaware of the funding source, including Harvard's B. F. Skinner who received $5,000 towards research on his book *Freedom and Dignity*. When informed that the CIA had provided his grant, Professor Skinner's response was simple: "I don't like secret involvement of any kind. I can't see why it could not have been open and above board." [*Nature* 278, 200, 1979.]

Harvard's president Derek Bok takes a less benign view of CIA campus activity. In testimony urging strong legal restraints, he revealed that "[letters], as well as direct discussions with the CIA, make it clear that the CIA plans to ignore... central elements of our guidelines." The Harvard guidelines require notifying the administration of CIA ties with individual professors, ban the use of academic employees in covert intelligence



activities, and prohibit a recruiting investigation (i.e., contacting teachers) until a targeted student has been notified. (CIA director Stansfield Turner admitted at 1978 AAUP meeting that the CIA continues to recruit foreign students on U.S. campuses.) [*Science* 201, 796, 1978.]

Considering the history of our political police and the revelations under the Freedom of Information Act, it seems the only way to safeguard academic and scientific freedom is to abolish both the CIA and the FBI.

## Wheeler Plays Dice with the Universe

In the *Newsweek* (12 Mar 79) commemoration of Einstein, Sharon Begley reports on the fate of the causality principle in "modern physics." Texas U. physicist John Archibald Wheeler is quoted as saying:

> What is so hard is to give up thinking of nature as a machine that goes on independent of the observer. What we conceive of as reality is a few iron posts of observation with papier-mache construction between them that is but the elaborate work of our imagination.

Begley describes Wheeler's ingenious "thought experiment" to suggest how an observer helps determine the reality perceived. It's based on the game of "twenty questions" in which one player leaves the room while the others choose a word the player is to guess on return. In Wheeler's version, however, the rules are changed while the player is out. The other players decide to select no word at all; instead, each will answer "yes" or "no" based on any word in mind that fits this reply and all previous replies. Wheeler's "experiment" proceeds thus:

> When the questioner begins, he assumes a word already exists, just as physicists beginning an experiment think reality already exists. Yet... if the player asks different questions, he finds a different word, and if scientists perform different experiments, they find different realities. Just as the word does not exist until it emerges from the question asked, says Wheeler, no phenomenon is a phenomenon until it is observed. "For our picture of the world, this is the most revolutionary thing discovered," says Wheeler. "We have still not come to terms with it."

Carlos Castaneda wrote of *A Separate Reality* to be attained by the ingestion of psychotropic plants. Professor Wheeler, however, seems to get just as "high" on the idealist philosophical concept of a world that does not exist independent of the observer. He might be surprised to learn that his "revolutionary" discovery was old even when it was discovered by Bishop Berkeley in 1710 (cf. Lenin's *Materialism and Empirio-Criticism*). This old form of idealism comes garbed today in the "new and modern" 20th-century statistical interpretation of quantum mechanics which Einstein himself never bought. To the end of his life, as Ms. Begley noted, he insisted that there is an underlying causality, saying "God does not play dice with the universe." □

## THE DIALECTICS OF MATERIALISM

The philosophical issues of the CETI discussion (pages 31-38) revolve around something quite fundamental to Marxism, namely, the *unity of opposites* embodied in dialectical materialism itself. In the philosophical examination of a practical scientific problem, the dialectical aspects concern reciprocal relations, developmental processes and so forth, while the materialist aspects concern causal relations, empiric content (the nature of the data, and how it is manipulated), etc. Obviously, when the material empiric basis is insufficient, the dialectical heuristics are deprived of content and any conclusions about the subject investigated will inevitably tend to go beyond the realm of science–into science fiction, metaphysical dogma, or both.

Since this journal is devoted to demonstrating the usefulness of Marxist dialectics in natural science, our interest here is not in the subject of CETI itself but in the questions that have been raised concerning the vital unity of *interpenetrating* materialism and dialectics. This philosophical issue has been brought out quite sharply in relation to Shklovsky's change of position on ETI (pages 33, 35, 37). I suggest that his shift from optimism to pessimism may represent a dialectical response to the material considerations of the concrete problem, a response that gives due weight to the materialist aspect of dialectical materialism.

In fact, such a shift in position of 180° offers us an insight on the essential contradiction between the materialist and dialectical aspects of scientific thought. It is often necessary to look at a subject from shifting and even opposing viewpoints in the exploratory effort to uncover regularities that will provide a basis for theoretic formulation. Marxism in no way inhibits such speculation on scientific problems. The need to "hang loose" mentally is evident in Lenin's comment on Aristotle's *Metaphysics*:

> Scholasticism and clericalism took what was dead in Aristotle, but not what was *living;* the *inquiries*, the searchings... Aristotle's logic is an inquiry, searching, an approach to the logic of Hegel—and it, the logic of Aristotle (who *everywhere*, at every step, raises *precisely* the question of *dialectics*) has been made into a dead scholasticism by rejecting all the searchings, waverings and modes of framing questions. [*Philosophical Notebooks*, pages 268-369.]

On the other hand, the usefulness of any conclusions drawn from an investigation will depend not so much on the method of search as on the dependability of the conclusions. Marx, Engels and Lenin always stressed the need for adequate empiric data as the basis for taking action, as a crucial aspect of the dialectical interaction between theory and practice in the scientific process. □



SCIENCE AND NATURE

## THE DIALECTICAL CONNECTION . . .

Philosophical materialism is inherent in the scientific process, in the very principle of causality. But the materialist principle, standing alone, can degenerate into a mechanistic view of the world. Such a one-sided outlook leaves the door open for its opposite which is philosophical idealism with its tendency to mystification. Idealism tends to ignore the universal interconnection of all material phenomena, and obscures the objective laws of change and development in nature and science. To shut the door on idealism, dialectics is necessary. It provides the philosophical connection between materialism and the constantly changing reality of the material universe.

*Dialectical materialism,* the philosophy originated by Marx and Engels, is the only *scientific* philosophy because it is the only philosophy that is rooted in the scientific process itself and thus can grow and develop with science. This journal is devoted to demonstrating the usefulness of Marxist dialectics in the practice of natural science. If you like what you read here, send us a subscription (see inside front cover) and tell your friends about *Science and Nature.*

**A beginnner's bibliography of Marxism in natural science:**

*Reader in Marxist Philosophy.* Howard Selsam and Harry Martel, editors. International, New York 1963. Paper $3.50, cloth $7.50. A marvelous sampling of cogent excerpts from Marx, Engels and Lenin.

*Fundamentals of Marxist-Leninist Philosophy.* F. V. Konstantinov *et al.* Progress, Moscow 1974. Cloth $4.50. (Available from Imported Pubns., 320 West Ohio St., Chicago, ILL. 60610.) Emphasizes the interaction of philosophy and the scientific process.

*Materialism and Empirio-Criticism.* V. I. Lenin. International, New York 1970. Paper $2.95, cloth $7.50. A scientific polemic against the idealist concepts of physicist Mach and his followers.

*Dialectics of Nature.* Frederick Engels. International, New York 1940. Paper $2.85, cloth $7.50. Though incomplete, this posthumous work is a brilliant beginning toward systematic treatment of the subject.

*Dialectical Materialism.* Maurice Cornforth. International, New York 1972. Three volumes, paper $5.00. An excellent introduction to the Marxist theory of knowledge, to materialism and the dialectical method, and to historical materialism.

**Everybody welcome**
**to another**
**DIALECTICS WORKSHOP**

*Sat., 1st Dec. 1979, 10 am to 4 pm*
*Columbia University, Pupin Hall*
*Entrance: 550 West 120th Street*

*INVITED PAPER*

**The Crisis in Particle Physics**
**Lloyd Motz, Astronomy**
**Columbia University**

*CONTRIBUTED PAPERS*

Submit by 1st Nov. one-page abstract for 20-minute talk that relates Marxist philosophy to natural science. Hyman R. Cohen, Workshop Secretary, 130 St. Edward, Brooklyn, NY 11201.

*The summoner: Greek actor, 4th cent. BC, The Louvre*

**And in Canada:** A Workshop in the Dialectics of Nature is planned for Toronto in academic year 79-80. Those interested may contact Stan Jeffers or Wayne Cannon, Dept of Physics, York University, M3J 1P3, or Frank Cunningham, Dept. of Philosophy, University of Toronto, M5S 1A1.

**Also Local Groups.** Informal discussion is another way to satisfy the widespread hunger for a useful philosophical approach to natural science. Study material may include articles from this journal. Two such groups already exist:

*Washington D.C. area.* Marxism and Science Class, P.O. Box 507, Bladensburg, Maryland 20710.

*Montreal Area.* McGill Science Discussion Group, c/o Shawn Lovejoy, 1106 Laurier est, Montreal, Quebec H2J 1G7, Canada.

*Leadership on the Campus.* Demonstrating the power of Marxist methods for the approach to practical and theoretical problems of natural science helps to further the ideological development of students, teachers and intellectual workers in general.