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PHILOSOPHICAL AND HISTORICAL ASPECTS OF THE ORIGIN OF LIFE

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At the 1978 AAAS meeting in Washington, a group of enthusiasts poured a jug of water over the head of Edward Wilson, castigating him as a racist and fascist. Many of my scientific colleagues were appalled; to them, real scientists simply do not behave in this manner. They accepted the image of science as expressed by Louis Pasteur when he wrote: «No religion, no philosophy, no atheism, no materialism, no spiritualism, belong in science» (1). It is not surprising that they view science in this way. It is part of the image of science conveyed to them by their teachers and by the textbooks that they read. Scientists, we are told, deal only in facts and the objective assessment of such facts. Their life as scientists must be totally divorced from their social, political, and theological life outside of science; the one must not impinge on the other.

To such people the current controversy over Sociobiology is not a scientific debate at all. It arose, they argue, because a group of leftwing radicals and even Marxists found the views of Wilson and others to be utterly incompatible with their political ideology. Thus, instead of debating the issue on its scientific merits, they chose to dismiss Sociobiology by labelling its adherents as racists and fascists – the modern descendants of Social Darwinists and Eugenicists (2).

To those who have become enthralled by the history of science, this political controversy over Sociobiology is not an abnormal situation at all. It may well be primarily a political debate, but contentious issues in the history of science have very often involved such non-scientific factors. One cannot separate social, theological, philosophical and political issues from the history of science without contorting the true picture. Whether this is good or bad is beside the point; history must attempt to deal with what exists, not with what should exist. To portray the history of science as a narrative of discoveries by objectively

minded scientists rigourously applying the scientific method, and to ignore the extra-scientific issues that may have been involved, is, in my way of thinking, to portray a completely inaccurate picture.

One must also be honest with oneself. Many years ago the great French physiologist Claude Bernard remarked:

> *It is impossible to devise an experiment without a preconceived idea; devising an experiment, we said, is putting a question; we never conceive a question without an idea which invites an answer. I consider it, therefore, an absolute principle that experiments must always be devised in view of a preconceived ideal.* (3).

Neither can historians of science approach their subject without preconceived ideas. To even believe that extra-scientific factors can impinge on science may well reflect certain political preconceptions of the believer. Persons of left-wing leanings are prone to stress the interplay of social forces in history and to underplay the influence of individuals and their ideas. Indeed, it also has been argued that the idea of science as an ideology-free discipline, advancing solely through discoveries of individual scientists, is itself a reflection of Western middle-class values.

This, of course, presents a problem. Precisely because both views of the history of science may have political overtones, and thus it becomes very difficult to engage in any meaningful dialogue. It must be admitted, however, that although there has been a great deal of rhetoric generated about the interplay of social forces in science, very few case histories exist which detail such influences. One of the best is Paul Foreman's study of physicists in Weimar Germany (4), and I believe also that the history of the spontaneous generation controversy and debates on the origin of life also provide substantial evidence in favour of such interpretations (5).

Before I discuss these controversies, I should state that I believe non-scientific factors have influenced science in three broad areas. First, and with this there can be little disagreement, such factors have influenced the quantity and quality of scientific output. The quantitative production of 19th Century German scientists, and the type of work they did, cannot be understood without reference to the research laboratories in the German universities, which had no counterparts anywhere else in the world until the end of the century. Likewise, the place of science in the fabric of 19th Century British society explains why their science differed so markedly from that of the Germans. One can hardly imagine *The Origin of Species* being written by anyone other than a British naturalist. In more recent times the interest in food-chains resulted from concern with radioactive fall-out, and how could a future historian ever explain the modern explosion in ecological research without reference to the Western concern with pollution?

Beyond this, however, the status of non-scientific factors becomes a matter of controversy. Do such factors also influence the choices scientists make between conflicting scientific theories? Do they even influence the formulation of these theories themselves? To answer such questions in the affirmative, as I do, demands proof.

* * *

After 1859 scientists were faced with a series of choices over the theory of evolution and the origin of life. For in one of those freakish accidents, the year that Darwin published his *Origin of Species* was also the very year when Louis Pasteur began his attacks on the theory of spontaneous generation. Herein lay the dilemma: if one accepted that life evolved by natural causes then one must also, to be consistent, accept that life arose by natural causes, namely by a spontaneous generation. But

at the very time when the evolutionary theory was growing in popularity, the possibility of spontaneous generation seemed more and more remote. How could one extricate oneself from such a dilemma?

In general terms the British, French and Germans reacted to this problem in very different ways, suggesting thereby that cultural factors were involved. If there were indeed an international «republic of science», then surely no such marked national differences would have occurred.

The French reaction was the most clear-cut. They solved the dilemma by denying both spontaneous generation and evolution. Indeed to the French, the seeming disproof of spontaneous generation by Pasteur was one of the most telling arguments they used against Darwin (6). The theory of evolution was not legitimate, argued Ernest Faivre:

> *Neither by its principle, which is conjecture; neither by its deductions which have no basis in reality; neither by its proofs which are hardly possible; neither by its two extreme consequences which science as well as human dignity forbid us from accepting: spontaneous generation and the intimate and degrading relationship of man and brute* (7).

More to the point, it seems fairly clear that the French reaction to evolution and spontaneous generation involved theological and political factors. Since the middle of the 18th Century, science had been a weapon in the hands of the social critics. Science, it was argued, was an agent of Enlightenment and the enemy of Authoritarianism. As Condorcet remarked in his *Lettres d'un Theologien* in 1773:

> *Any man who makes a profession of seeking and announcing the truth, will always be odious to those who exercise authority... The more men are enlightened, the less those with authority can abuse it. Thus truth is the enemy of power, as of those who exercise it.*

Not surprisingly, therefore, in the aftermath of the French Revolution many anti-republican writers blamed these social critics and their ideas for the horrors of that period. Naturally the ideas which they found most repugnant and dangerous were those with materialistic and atheistic overtones. «What a victory for materialism», Pasteur exclaimed in a public address in 1864:

> *If it could be affirmed that it rests on the established fact that matter organizes itself, takes on life itself; matter which has in it already all known forces. Ah! If we could add to it this other force which is called life... what would be more natural than to deify such matter? Of what good would it then be to have recourse to the idea of a primordial creation? To what good then would be the idea of a Creator God* (8).

Once we admit the possibility of spontaneous generation, Pasteur went on to warn his audience, then it would be no more surprising to learn also that beings «transform themselves and climb from rank to rank, for example to insects after 10,000 years and no doubt to monkeys and man after 100,000 years.»

Such materialistic ideas obviously had both political and theological overtones, which was of particular significance during the Second French Empire. After years of political uncertainty, the Paris «mob» had once more exploded in the bloody June riots of 1848. French society was once again polarized; in the words of Alexis de Tocqueville it was a society «split in two: those who possessed nothing united in a common greed; those who possessed something in a common fear.» In the aftermath of these riots, fear was also the driving force which turned the French middle class towards the Catholic Church. The Church stood for a stable social hierarchy and social order. Church and State stood shoulder to shoulder in face of the common enemy. During the Second Empire a theological attack on church doctrine also became a political attack on the State. The choice, it seemed, lay between Louis Napoleon or «the complete ruin of France.»

The Church itself moved considerably to the right. In the year that Pasteur had addressed the problem of materialism, Pope Pius IX had issued his infamous encyclical condemning any attempt by the Church to compromise itself against forces of modern liberalism. One such force was clearly the doctrine of evolution. In 1862 the first French translation of Darwin's *Origin of Species* had appeared, under the pen of that notorious atheist, materialist and republican, Clémence Royer.

Royer had made the political and theological implications of Darwin's theory abundantly clear. To her translation she attached a lengthy preface in which the Catholic Church was attacked with great vehemence. It was a religion, she wrote, *«which was spread by an ignorant, domineering, and corrupt priesthood.»* It was a religion, she went on, *«which had put an end to all possible progress of all science and all philosophy»*, and one which had *«impeded progress for fifteen centuries and still does not cease to impede it in our day»* (9). Materialism and evolution were highly provocative terms to the French and spontaneous generation was intimately related to both!

Against such a backdrop it is not surprising that opponents of evolution and spontaneous generation should have used both theological and political arguments. Neither is it surprising that the disproof of spontaneous generation by Pasteur – at least that is how the French interpreted Pasteur's work – should have been seen as powerful scientific and theological evidence against the theory of evolution. As the essayist Alfred Sudre remarked:

> *We find ourselves safeguarding the supernatural origin of life, creation in the animal domain, the permanence of types, the unity of humanity, these great truths which form, so to say, the point of intersection and the reciprocal sanctions of the biological and the moral sciences* (10).

Thus, it appears clear to me that the choices made by French scientists over the question of evolution, of spontaneous generation, and the relationships between the two, reflected in part the theological and political implications of these questions. For as Louis Pasteur remarked, *«the fixity of species, or the slow and progressive transformation of one species into another; the eternity of matter; the idea of a useless God»*, were the *«great problems»* of the day (11). A French scientist simply could not view the issue in a cold objective light, anymore than modern Americans can calmly discuss the sociobiology issue – too much was at stake.

The dilemma of evolution and the origin of life was resolved in totally different ways by the British and Germans, since the majority of them, unlike the French, came to accept the evolutionary theory. For their part, the British avoided the issue by arguing that a belief in evolution was perfectly compatible with a belief in Divine Creation. None other than Thomas Henry Huxley remarked in 1860 that *«with respect to the origin of this primitive stock, or stocks, the doctrine of the origin of species is obviously not necessarily concerned. The transmutation hypothesis, for example, is perfectly consistent either with the conception of a special creation of the primitive germ, or with the supposition of its having arisen, as a modification of inorganic matter by natural causes»* (12). Neither the French nor the Germans could accept such an argument. That the British were able to essentially avoid the issue reflects in part the strong influence of Natural Theology on their science, but more, I think, the particular style of British science at that time. The British were above all empiricists following the inductive methods of Francis Bacon and that view of science expressed in the famous dictum of Sir Isaac Newton: *Hypotheses non fingo*. To even consider the question of the origin of life represented the type of absurd speculation that had no place in science. They saw

themselves as being concerned primarily with hard facts. Charles Lyell, the famous British geologist, was very anxious to differentiate geology from cosmology. The former, he wrote, *«investigates the successive changes that have taken place in the organic and inorganic kingdoms of nature»*, while the latter dealt with «the origins of things» (13). Scientists merely described nature, or as *The Times* of London put it, *«we look to men of science rather for observation than for imagination»*. Although, of course, this attitude did reflect a certain philosophical viewpoint, the British were more prone to consider their science as completely devoid of philosophical influences.

Philosophical influences were, on the other hand, the prime factor in the development of German scientists' answers to the paradox of evolutionary theory and the origin of life. Factor in the development of evolutionary theory and the origin of life. By the middle of the 19th Century, biological sciences in Germany were dominated by reductionist and mechanistic philosophies. A widespread revulsion towards the earlier speculative *Naturphilosophie* had motivated the formation of the famous Physical Society. The members of this society, Hermann von Helmholtz, Emil du Bois Reymond, Ernst Briicke and Karl Ludwig, had joined together in 1847 in an attempt to *«constitute physiology on a chemico-physical foundation and give it equal rank with Physics.» «Physiologists must expect to meet with an unconditional conformity to the law of the forces of nature in their inquiries respecting the vital processes»*, remarked Helmholtz, *«they will have to apply themselves to the investigations of the physical and chemical processes going on within the organism»* (14).

Initially they opposed the doctrine of spontaneous generation because of its early association with *Naturphilosophie*, but with their acceptance of Darwin's theory and their abhorrence of any theological explanations in science, they came to view the origin of life as *«an exceedingly difficult mechanical problem.»* By the 1870's, when the theory of spontaneous generation had at last collapsed in Germany, this mechanical problem had become even more difficult. In an attempt then to adhere to their belief in physical causality, some of them transferred their support to the doctrine of cosmozoa, the belief that life had originated from germs entering the earth from outer space. Such a belief, of course, enabled them to deny the possibility of spontaneous generation, while at the same time accepting the evolutionary theory and denying any Divine Creation.

Others of this general philosophical outlook, however, refused to avoid the issue in this way. They were forced to admit the origin of life by a spontaneous generation. *«To deny spontaneous generation»*, Karl von Nägeli exclaimed, *«is to proclaim a miracle.»* It was, as one remarked, *«an act of philosophical faith»* (15).

This act of faith was also shared by Ernst Haeckel and the more extreme school of German materialists. This latter group, made up of such notables as Ludwig Büchner, Karl Vogt and Jacob Moleschott, had shocked the sensitivities of the Victorian age with such remarks as: *«thought is secreted from the brain, as bile from the liver or urine from the kidneys»*. They had also been the first to raise the question of the origin of life. *«If every organism is produced from parents, whence came the parents?»* demanded Buchner in 1855. *«Could they have arisen from the merely accidental or necessary concurrence of external circumstances and conditions, or were they created by an external power? And if the first supposition be true, why does it not happen today?»* (16). Why not indeed. Although this last question was never really answered they continued to believe that life must have originated by a spontaneous

generation even though it seemed not to occur at the present. Their particular brand of materialism could accept no other conclusion. The scientific evidence in opposition to spontaneous generation was of minor concern.

It seems fairly clear that the choices made by 19th Century scientists about the problem of spontaneous generation and the origin of life involved a great deal more than a simple objective evaluation of scientific evidence. Political and theological issues loomed large in France, while philosophical issues were of paramount significance in Germany. Neither approach managed to resolve the issne. Scientists ignored the problem, as the English physiologist E. E. Schaefer remarked in 1912, *«by relegating its solution to some former condition of the earth's history, when it is assumed, opportunities were accidently favourable for the passage of inanimate matter into animate: such opportunities, it is also assumed, having never recurred and being never likely to recur»* (17). That this view made little sense was of little concern to most scientists. As William Preyer pointed out in 1880, if the past had been so totally different from today's conditions that spontaneous generation could have occurred, then the organisms so produced would have perished instantly. Life, as is well known, can only exist over a very narrow range of environmental conditions. If, on the other hand, conditions in the past were quite similar to those of today, then there is no reason why spontaneous generation could not be a constantly reoccurring phenomenon (18).

This totally illogical position became even more precarious in the early decades of the 20th Century. The issue was ignored during the latter years of the 19th Century, basically because even the most simple living organism was considered to be extremely complex. The hiatus between life and nonlife was so wide that it seemed impossible to bridge by any fortuitous meeting of molecules. But between 1905 and about 1930 the gap between life and nonlife narrowed to such an extent that there appeared to be no discontinuity. Spontaneous generation once more became a feasible explanation for the origin of life, but at the same time it became even more difficult to explain why spontaneous generation was not occurring at the present.

The nature of the simplest living form and thus of the first living form was now considered to be a piece of *«living matter»*. Life, it was realized in these years, could be manifested at a level below the cell, and the simplest forms of living matter were essentially similar to inanimate matter.

This change in attitude towards life was primarily the result of a new discipline, biochemistry, that arose in the early years of the 20th Century. While 19th Century chemists were concerned with the separation and analysis of living protoplasm, biochemists focused on the dynamic aspects of cellular metabolism. Life was no longer attributed to the structure and properties of protoplasm, but to the activities of specific enzymes in a self-regulating dynamic equilibrium. They pioneered the *«age of biocolloidology»*, when colloidal aggregates or micellae were thought to exhibit properties essentially similar to living processes. Thus, as one biochemist remarked in 1925, the distinction between primitive life and inorganic colloids was merely a *«mental barrier»*. Workers in the new field of virology tended to agree. *«Life»*, remarked Félix-Hubert d'Hérelle, one of the early virologists best known for his work on bacteriophages, *«does not require a cellular organization»*. Instead *«it results from a special physico-chemical state of matter, that is the protein micella, the smallest particle of matter in the colloid state»* (19).

The spontaneous generation of these colloidal aggregates obviously presented no

problem to these early virologists and biochemists. *«When we seek to explain the origin of life»*, wrote Archibald Macallum, professor of biochemistry at the University of Toronto, *«we do not require to postulate a highly complex organism»*. It is merely necessary to generate a colloidal particle, which *«is in a definite sense, alive»* (20).

What precise form this ancestral living matter took was never made clear. A whole host of different entities was suggested: an autocatalytic protein enzyme perhaps, a piece of chromatin, a unimicellar being, or even a moleculobiont. In 1926, the famous American geneticist H. J. Muller argued that life did not occur before the gene, and that *«the first material probably consisted of little else than the gene or genes»*. In the U.S.S.R. the biochemist Aleksandr Oparin argued for the similarity between colloids and protoplasm and maintained life arose when the first gel came out of a colloidal solution (21).

It is clear that this change in attitude towards spontaneous generation was generated from within science itself, from virology and biochemistry. Moreover it also reflected a strong reductionist tendency in the sciences of that period. The sciences were once again arranged in a hierarchy, with physics at the base and the social sciences at the apex. Every science drew its explanations from those below. The social sciences were reduced to the deterministic laws of biology, and biological processes, it was argued, could only be understood by reducing them to their single isolated component parts. Thus, as in the 19th Century, life was thought to have arisen when these parts came together by chance to produce the first living material. But, although such living matter was now thought to be very simple, scientists were still very reluctant to admit that it could be generated at the present. Biologists were thus confronted with the same dilemma that had faced them in 1859.

By the 1930's however, the innate complexity of living forms was once again being stressed and reductionism was being subjected to criticism. Taking an anti-reductionist position, Oparin argued in 1936 that it was inconceivable that even the simplest form of life could *«appear in a very short time, before our eyes so to speak, from unorganized organic solutions»*. Life did not appear spontaneously when the last piece of machinery fell into place, he argued, rather *«it must have resulted from a long evolution of matter, its origin being merely one step in the course of its historical development.»* Life did not arise in a moment, it emerged gradually (22).

The concept of emergent evolution was not unique to Oparin. Conwy Morgan and others had discussed the phenomenon in philosophical terms earlier in the century. The mechanistic interpretation of life, Morgan relates, *«regards life as a regrouping of physico-chemical events with no new kind of relatedness expressed in this integration.»* Emergence occurs, on the other hand, when new and unpredictable phenomena arise as a result of combining separate elements. Thus, for example, the properties of protein molecules cannot be foretold in advance by simply knowing the properties of each constituent atom, they are something essentially different (23).

What was so unique in Oparin's text of 1936, *The Origin of Life*, and the source of its considerable impact, was the specific details he presented for the stages of this emerging process. It was far more than a vague statement that 'life emerged'. The transition between one stage and the next could now be subjected to experimental testing, and for the first time the origin of life became a legitimate biochemical research problem. Very soon after the end of World War II, the usual manifestations of a new research area appeared: the calling of international conferences on the origin

of life and the eventual appearance of a journal devoted exclusively to this topic. Indeed, most of the authors of the present volume owe their professional status almost entirely to their work in this field. Their debt to Oparin is immense. Oparin's book, George Wald once remarked, *«provides the foundation upon which all of us who are interested in this subject have built»* (24).

But if this explains the general reaction of biochemists to Oparin's work, it does not explain much of the hostility expressed towards it by biologists in other fields. Neither does it explain the genesis of Oparin's ideas. Here again extra-scientific factors were involved (25).

Between 1927 and 1929 Stalin launched his cultural, industrial and agricultural revolution, during which the control of science passed into the hands of the Soviet Communist Party. As a result, attempts were made to build a new science of the proletariat, dedicated to practical ends for the benefit of the Soviet people. Oparin, in 1935, published a work dealing with the biochemical basis of tea production, and most infamous of all, Trofim Lysenko addressed himself to the problem of *«vernalization»* of winter wheat. He announced in 1929 that wheat, normally planted in the autumn and thus subject to severe winter kill, would ripen after a spring planting if subjected to moisture and low temperatures immediately prior to planting (26).

At the same time many Soviet scientists began a conscious reconstruction of their science based on Friedrich Engels' dialectical materialism. During the 1930's Trofim Lysenko, for example, used the rhetoric of dialectical materialism to attack classical Mendelian genetics, thereafter providing a powerful weapon in the hands of those who argue that ideology has no place in science (27). Such critics have ignored the fact that Oparin also utilized dialectical materialism as a framework from which to address the problem of the origin of life. In Oparin's case, however, the arguments were very persuasive and the results highly successful.

The framework of dialectical materialism led Oparin to view life as a complex interaction of chemical processes and not as the property of a specific chemically defined substance. Thus he was opposed to the idea that life arose when a specific molecule came together by chance. Through Engels' law of the Transformation of Quantity into Quality, he came to view the beginning of life in terms of emergence. Thus, as more and more complex molecules developed, *«the old laws of physics and chemistry naturally continued to operate, but now they were supplemented by new and more complicated biological laws which had not operated before»*, and which, of course, could not be predicted from the properties of the isolated molecules. As Harold F. Blum remarked in his *Time's Arrow and Evolution: «We must abandon the idea of a definite moment of origin and assume that a series of events represents the beginning of life rather than one definite point in this series.»*

Biochemists in the 1950's were thus faced with a choice between Oparin's hypothesis of emergent evolution and the older hypothesis that a living molecule spontaneously arose by chance. How was this choice made? Did Oparin's Marxist interpretation play any role in subsequent debates on the issue?

At first glance one might have expected Western scientists to have reacted negatively to Oparin, in the same way that they responded to Lysenko. The cold war loomed large in the 1950's, left wing dissenters were subject to personal harassment as Senator McCarthy carried out his vendetta against liberal elements in the United States. Yet, in fact, American and other Western biochemists became rapidly converted to the Oparin thesis.

As argued above, the reasons for this conversion seem clear. For the first time biochemists saw the origin of life question as a legitimate scientific research problem and reacted to Oparin on those terms. If this implies that indeed scientists are totally indifferent to any political ramifications of their theories, one must temper it by stating that they seemed totally unaware of the Marxist basis of Oparin's theory. I was myself exposed to Oparin's work as an undergraduate in the 1950's, but neither myself, my peers, nor my instructors had the least idea that Oparin was presenting a dialectical argument. This was not because Oparin in any way covered up his dialectical views. In a much revised and enlarged version of his text, published in 1956, he wrote:

> *A completely different prospect opens out before us if we try to approach a solution to the problem dialectically rather than metaphysically, on the basis of a study of the successive changes in matter which preceded the appearance of life and led to its emergence. Matter never remains at rest, it is constantly moving and developing... Life thus appears as a particular very complicated form of the motion of matter, arising as a new property at a definite stage in the general development of matter* (28).

We remained unaware, I think, because of total ignorance of dialectical materialism. Few Anglo-Saxon scientists these days know anything about philosophy, let alone Marxist philosophy. Why should they? If science is free of extra-scientific influences, then a scientist's training need not include any. Thus in the West, «two cultures» have arisen! I did not become aware of the basis of Oparin's views until reading Loren Graham's *Science and Philosophy in the Soviet Union*, published in 1972. Indeed, the reaction to my own recently published book on the history of the spontaneous generation controversy has led me to conclude that it was the vehicle by which many scientists first learned of Oparin's approach. One cannot, therefore, refrain from wondering how these biochemists would have reacted to Oparin in the 1950's had they known.

But one group of Western-trained scientists did oppose Oparin's work. These were the geneticists and phage workers, who opposed Oparin not in reaction to his Marxist views, but because he was a supporter of Lysenko. This group tended to agree with H. J. Muller, when he wrote: «All material in the organism is made subsidiary to the genetic material, and the origin of life is identified with the origin of this material by chance chemical combination» (29).

They tended to couple Oparin's views with those of Lysenko, believing both to represent a threat to the validity of classical Mendelian genetics. The maintenance of status has always been an important motivation of choice! This immediately takes on political overtones. The Soviet Communist Party had banned teaching and research in classical genetics as part of its ideological support for Lysenkoism, and Muller had visited the Soviet Union in 1933 only to become a life-long opponent of Stalinism and Lysenkoism. As late as 1966 Muller had described the books of the *«Lysenkoist Oparin»* as *«part of the attempt to down-rate the significance of genetics»* (30).

The Lysenko controversy was very much evident during the first International Symposium on the Origin of Life which took place in Moscow in 1957. For example, Wendell Stanley's paper *«On the nature of viruses, genes* ad live», in which he had argued that with nucleic acids *«we are dealing with life itself»*, was attacked by the Soviet geneticist Nikolai Nuzhdin. Stanley's paper, Nuzhdin argued, represents *«the ever-growing tendency to ignore the qualitative specificity of living material which distinguishes it from non-living material»*, a tendency which entered biology as a result of the work of physicists who *«consider the possibility of a more com-*

plete explanation of biological phenomena solely in terms of their understanding of the laws of physics and chemistry.» Nuzhdin, it need hardly be mentioned, «*had paid much attention to the problems of the struggle with anti-Michurinist distortions of biology, constantly criticizing various idealistic trends in the study of variation and heredity*» (31).

I hope my brief discussion has convinced the reader that the historical background to our present interest in the origin of life is more complex than most scientists believe and perhaps like to believe. The story of the spontaneous generation debate illustrates the falsity of the claim that science is a product of scientific geniuses whose ideas are generated solely from within science itself. In the words of a recent reviewer, the spontaneous generation story is one of «*biology, medicine, theology, metaphysics and politics, a panorama of scientific thought and work, a medley of earnest Christians, devoted atheists, and agnostics, convinced or conforming Marxists*» (32).

In the past, people felt strongly about the issue of spontaneous generation, as they now feel strongly about racial inequalities. In both cases the intensity of belief went far beyond what legitimately could be held on scientific grounds alone. If our 18th and 19th Century ancestors did not throw water at each other, that merely reflects a cultural difference between Europeans and modern Americans. Personally I would prefer drying clothes than being subject to these biting words of Henri Milne Edwards:

> *When the savage tribes of one of those isolated oceanic islands saw shipwrecked sailors for the first time, they thought that these strangers were descended from heaven, or like fishes, had arisen from the sea-bed. They did not stop to think that they came from an unknown island beyond the horizon. Partisans of spontaneous generation seem to me to reason in the same manner as those ignorant islanders.*

E. H. Carr, in his book *What is History*, points out that history is never and cannot be a description of reality. It is made by historians. Thus to study history one must «*study the historian before you study his writings.*» Likewise, it seems to me, science is made by scientists. To fully understand a scientific theory one must also first understand the scientist who proposed the theory and the milieu in which he existed. Although the results of such inquiries may well be somewhat abhorrent to the ideologies of modern scientists, I hope they will at least withhold judgement until, in their own words, «*all the facts are in*».

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17. SCHAEFER A.E. «Presidential Address to B.A.A.S.» *Report of* B.A.A.S. (1912), p. 13.
18. WILLIAM PREYER, *Die Hypothesen uber den Ursprung des Lebens* (Berlin, 1880).
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