The strand which we have just followed in nineteenth-century thought was concerned with the failure of the critical, analytic understanding to grasp what is essential in man and what is essential with respect to his place in the world. In Germany, as we saw, it originally arose out of Kant's distinction between the Understanding and the Reason, and involved a rejection of his view that all knowledge is based on sensibility and conforms to the categories of the Understanding. The movement which we shall now examine arose in the mid-nineteenth century and returned to a position which was in this respect similar to that of Kant: our knowledge is circumscribed by the limits of sensibility and by the manner in which our minds organize that which is immediately presented to us.

Unlike Kant, however, those with whom we shall now deal did not hold that the categories are native to the mind; rather, they regarded them as acquired in the course of experience. Even more importantly, they differed from Kant in the stress which they placed on the fact that all human knowledge is circumscribed by the limits of sensibility. For Kant, this was a general epistemological limitation, demarcating the line between knowledge and belief; for the forms of positivism with which we shall now deal, the limitation was translated into basically physiological terms: our knowledge is necessarily limited by the nature of our sense-organs. In this respect, they not only differed from Kant but from earlier positivists; for example, neither Comte nor Mill formulated his views regarding the limits of knowledge in terms of the nature and limitations of our sense-organs. After the middle of the century, this was one the characteristic marks of positivism among scientists and scientifically oriented philosophers. As a consequence of it, these later positivists placed heavier stress than had Comte or Mill upon the distinction between that which is knowable and that which exists in itself. They justified the distinction by appealing to the fact that knowledge depends upon sense experience, and what we are capable of directly experiencing is a function of the sense-organs we possess.
One should not assume that this physiologically oriented form of phenomen­nalism is nothing more than an extension of the epistemological uses to which physiological data had often been put: for example, we are not here dealing with explanations of particular illusions in terms of the nature and the conditions of the sense-organs. Rather, a general epistemological position is put forward on grounds which derive from the positive sciences, and in this case from the physiological sciences in particular. This fact was insisted upon by Helmholtz, and the structure of Spencer's Principles of Psychology, in its radically rewritten second edition, affords clear evidence that such was also his view. In this shared view they were by no means alone.

In order to understand why this form of phenomenalism should have gained widespread acceptance, several factors must be taken into account. In the first place, the general position of phenomenalism had already been widely accepted, and did not have to be established as a new and unfamiliar view. To return to a doctrine of the limits of positive knowledge seemed to many an easy and welcome step. This was not only true of German reactions against post-Kantian philosophy, as one can note in Helmholtz; it was also congenial to those in England who had been influenced by Comte, or were sympathetic to Mill in his attack on Hamilton, or who were influenced by Hamilton and by Mansel, or who—as in the case of Spencer—had been influenced by each of these. Nevertheless, the fact that phenomenalism was a familiar type of position is not sufficient to explain why it was taken to have been established by developments which had occurred within the natural sciences. Here the specific influence of positivism upon scientists played an important role. It will be recalled that positivism held that genuine knowledge of a systematic sort can only be established by scientific means; therefore, it followed that if epistemological issues were to be definitively settled, they would also have to be settled by this means. While Helmholtz, Spencer, and others, such as Huxley, did not rigidly adhere to this position, their identification of reliable knowledge with scientific method was sufficiently strong to have led them to discuss epistemological issues in terms of the results which contemporary science had achieved. It is precisely at this point that the impact of the physiological sciences on epistemological issues is most clearly seen, for it was at this time, in the mid-century, that there was an important confluence of physical theory and physiological investigations. As a consequence, physiological investigations were fully incorporated into the body of the positive sciences, and had to be taken into account in any attempt to understand the relationships between man and the natural world.

In this connection, the views of the eminent physiologist Emil DuBois-Reymond are enlightening. His famous phrase "ignoramus... ignorabimus" provided the conclusion for a lecture in which he had not only attempted to show the limits beyond which scientific understanding could not go, but in which he had vigorously defended the truth of a mechanistic account of the world. Before turning our attention to his more eminent contemporary, Helmholtz, it will be useful to characterize DuBois-Reymond's view.

The first point to be noted is the fact that DuBois-Reymond placed physiology
squarely within the framework of a mechanical world-view, which he characterized in terms of a strict Laplacean form of determinism. That he did so should not be construed as suggesting that he was blindly taking over a traditional form of philosophic materialism; rather, in part at least, his position had been formed by a major theoretical advance in the empirical sciences: the formulation of the principle of the conservation of energy. In this connection one should recall that two of the formulations of that principle—those of Mayer and of Helmholtz—had originated within the context of physiological problems: in fact, Helmholtz's essay on the subject stemmed from his opposition to the vitalism of Stahl. Thus, when DuBois-Reymond argued that there is one set of laws which is basic for all nature, and these are the laws of theoretical mechanics, he was speaking of what he regarded as a necessary consequence of a major scientific revolution which had taken place in his time. The same attitude is to be found slightly earlier, in 1865, in Kirchhoff's rectoral address "On the Goal of the Natural Sciences," in which he had stated that there could be no understanding of the complex processes occurring in plants or animals until they were reduced to the principles of theoretical mechanics. In 1869 Helmholtz expressed a similar view in a lecture to a scientific congress which he entitled "The Aim and Progress of Physical Science." Considering the success of Helmholtz and DuBois-Reymond in their experimental work on nerve impulses, and the monumental treatises on physiological acoustics and optics which Helmholtz was able to construct, the view that physiology belonged among the physical sciences seemed to have become secure. Given the developments within theoretical mechanics, this meant that physiological processes must conform to the basic laws of mechanics, and vitalistic explanations were therefore to be regarded as wholly false. That this doctrine of the unity of all science should have been accepted at the time was not, then, merely a vestigial metaphysical prejudice: it seemed warranted as a conclusion to be drawn from empirical investigations in physiology and from the basic principles of physics itself.

It is precisely at this point, where all natural phenomena are held to conform to the fundamental principles of mechanics, that DuBois-Reymond claimed that one is forced, for the first time, to say "ignorabimus." His point was that we shall always remain in ignorance of why these ultimate forces act as they do: we can never understand "matter" in itself, nor "force" in itself, but we only know them through their manifestations. To be sure, when DuBois-Reymond spoke in this way, he was obviously supposing that a distinction is to be drawn between how things manifest themselves and what they actually are in themselves. It might then be thought that he was himself indulging in "metaphysics." However, the fact that he did draw this distinction was a consequence of what I have characterized as a physiologically oriented phenomenalism. It was his contention that the world in itself lacks all of the qualities which it appears to have as we experience it: what we experience depends upon the ways in which our nerves are affected, and this means upon molecular processes going on within the nerves themselves, regardless of how these processes were caused. Thus, the world conceived in physical-mathematical terms, and the world known in direct experience, seem to
bear no relation to one another. To be sure, if we could discover the relationship between nerve processes and the qualities to which they give rise, we could escape this predicament. However, it is precisely at this point, when the question arises as to how nerve processes are related to conscious experiences, that DuBois-Reymond found himself forced to say *ignorabimus* for the second time. Thus we cannot know the world as it exists independently of how it appears within our experience; all that we can say of such a world is that all events in it are in principle predictable on the basis of a single set of absolutely uniform laws, the laws of theoretical mechanics.

I need scarcely point out that this acceptance of Laplace's formulation of a complete determinism combines rather oddly with phenomenalism. Yet the belief that these doctrines could be combined was characteristic not only of DuBois-Reymond, but of Helmholtz and Spencer. However, unlike DuBois-Reymond, each offered a theory of knowledge which, if not entirely satisfactory, did recognize some of the difficulties, and did attempt to overcome them.

1. HELMHOLTZ: SCIENCE AND EPISTEMOLOGY

On the occasion of Helmholtz's seventieth birthday, he was presented with a book of essays written in his honor, *Beiträge zur Psychologie und Physiologie der Sinnesorgane*; this volume carried as its epigraph a quotation from one of his essays which, in translation, reads: "a metaphysical conclusion is either a false conclusion or a concealed experimental conclusion."¹¹ No more succinct statement of his basic positivism could be given. However, it is just as important to note the respects in which Helmholtz differed from some other positivists, as it is to see to what extent he agreed with their rejection of metaphysics. While he held that all knowledge is to be drawn from experience, and is to be confirmed through experience, he did not hold that such confirmation is ever direct. Therefore, as we shall see, he did not regard it as meaningless to speak, for example, of forces in nature which lie behind observable phenomena;¹² in this respect, he differed very radically from others whom one regards as "positivists." To understand why he rejected any theory which restricts our knowledge to that which we are capable of verifying through direct sense-experience, one must understand his views regarding the physiology of the senses.

A basic factor in his position derived from the views of his teacher, Johannes Müller, concerning "specific nerve energies." According to that theory, the afferent nerve fibers of the different sense modalities each have their "specific energies" so that regardless of how they may be stimulated—whether through external or internal causes—they excite the appropriate type of sensation. On this view, to cite simple cases which were cited by Müller, auditory sensations may be caused either by sound-waves emanating from an object or by a blow on the head, just as pressure on the eyeball, and not merely the stimulation of light, may cause sensations of color. The importance of this doctrine for the theory of knowledge consists, of course, in the fact that there cannot be assumed to be any qualitative resemblance
between the cause of a sensation and the sensation itself. Helmholtz was very explicit in drawing this inference from Müller's theory, even though he rejected the semi-Kantian manner in which Müller himself had used it. For example, in a series of lectures on "The Recent Progress of the Theory of Vision," delivered in 1868, we find him saying:

We have already seen enough to answer the question whether it is possible to maintain the natural and innate conviction that the quality of our sensations, and especially our sensations of sight, give us a true impression of corresponding qualities in the outer world. It is clear that they do not. The question was really decided by Johannes Müller's deduction from well ascertained facts of the law of specific nervous energy. Whether the rays of the sun appear to us as colour or as warmth, does not at all depend upon their own properties, but simply upon whether they excite the fibres of the optic nerve, or those of the skin. . . . The most complete difference offered by our several sensations, that namely between those of sight, of hearing, of taste, of smell, and of touch . . . does not, as we now see, at all depend upon the nature of the external object, but solely upon the central connections of the nerves which are affected.13

Or, as he says in another place, when discussing the extension of Müller's point of view to processes occurring within systems of nerve fibers in a single modality:

In this case it has been shown that no kind of physical similarity whatever corresponds to the subjective similarity of different composite light of the same colour. By these and similar facts we are led to the very important conclusion that our sensations are, as regards their quality, only signs of external objects, and in no sense images of any degree of resemblance.14

Yet, Helmholtz held that "apprehension by the senses supplies after all, directly or indirectly, the material of all human knowledge."15 Obviously, there were epistemological difficulties here which demanded solution. One among them was the problem of explaining how our senses could supply us with adequate information concerning material objects if all of the data of which we are conscious depend upon what goes on, so to speak, within our own skins.

The problem would be insoluble if what we demand is that our senses should provide us with images of independently existing material objects: however, it may perhaps be done away with if what we mean by a knowledge of material objects is a reliable system of signs which represent the relationships among the entities which our signs are taken as signifying. This was the path which Helmholtz followed:

An image [he said] must be analogous to the original object; a statue, for instance, has the same corporeal form as the human being after which it was made. . . . In the case of a sign it is sufficient that it become apparent as often as the occurrence to be depicted makes its appearance, the conformity between them being restricted to their presenting themselves simultaneously. The correspondence existing between our sensations and the objects producing them is precisely of this kind.16

According to Helmholtz, the difference between languages as systems of signs, and sense-perception as a system of signs, is that the system of our sensations is not
arbitrary, but is in fact a universal language of which there are not diverse families or differing dialects: it is the mother tongue of nature itself. Different people, he held, receive the same sensations from the same objects, and at different times an object which has not changed will excite the same sensations in us. Thus, the system of the sensations which are caused by objects will conform to the relationships existing within the field of those objects.

To be sure, one feature of the doctrine of specific nerve energies would seem to render the assumption of such a conformity dubious: as we noted, it was held that quite different types of stimuli can cause similar sensory excitations; thus, for example, a blow on the head can give us visual or auditory sensations. However, Helmholtz incorporated such facts into his theory by distinguishing between our awareness of sensory data and our perception of objects. For example, in his lectures on “The Recent Progress of the Theory of Vision,” which summarized the more general views developed in his *Physiological Optics*, he distinguished sharply between the *sensations* of sight, which depend upon how the eye is affected, and *perceptions* of sight, which depend upon unconscious inferences based upon past experience. Sensations, as such, can never be mistaken, but they may be mistakenly interpreted when we take them as signs of the existence of external objects. Furthermore, they may give rise to *illusions*, which depend upon faulty inferences due to the presence of unusual circumstances in the conditions under which sensations are presented to us:

When the modes of stimulation of the organs of sense are unusual, incorrect ideas of objects are apt to be formed; which used to be described, therefore, as *illusions of the senses*. Obviously, in these cases there is nothing wrong with the activity of the organ of sense and its corresponding nervous mechanism which produces the illusion. Both of them have to act according to the laws that govern their activity once for all. It is rather simply an illusion in the judgment of the material presented to the senses, resulting in a false idea of it.

He states his explanation of such illusions in the case of vision by means of the following rule:

*We always believe that we see such objects as would, under conditions of normal vision, produce the retinal image of which we are actually conscious.*

Taking these doctrines into account, we may say that what constitutes veridical perception is, simply, our capacity to infer, on the basis of normal past experience, how different sensory excitations are connected with one another, so that they form an interrelated system of signs, or cues. The unconscious inferences which are involved do not differ, according to Helmholtz, from *logical* inferences, except superficially, by virtue of the fact that logical inferences can be formulated in words, whereas the implicit inferences of perception only make use of sensations, and of the memory of past sensations.

When Helmholtz spoke of perceptual judgments in this way, what he had in mind was the fact that every such judgment consists in an *induction* based upon
past experience: like Mill, whose logical theory influenced him,\textsuperscript{21} Helmholtz was attempting to give what he termed an "empiristic" (empiristische) account of all human knowledge, showing that neither "intuitionistic" nor "nativistic" hypotheses had to be invoked in order to account for any aspects of our experience. In this connection we may note that, like Mill, he also offered an empiristic account of mathematics; this account, it is to be noted, included a consideration of non-Euclidean geometries. In a series of essays, he set himself the task of explaining how it is that, on the basis of imaginative experience, we can formulate various types of non-Euclidean systems, although our spatial experience is such that Euclidean geometry seems intuitively certain to us.\textsuperscript{22} In this field, as in all others, what Helmholtz wished to reject was the theory that there is "a pre-existing harmony of the laws of mental operations with those of the outer world"; it was his aim "to derive all correspondence between mind and matter from the results of experience."\textsuperscript{23}

It would seem that, if this were his aim, he was still in epistemological difficulties. As we have seen, he had rejected the idea that our sense-experience, which is the sole source of our knowledge, could be assumed to resemble the external world: knowledge consisted in a set of usually reliable signs, or cues, as to simultaneities and sequences within what we experience. How then could Helmholtz establish any form of correspondence between what is experienced and what exists independently of us? The answer to his question lies in the fact that, unlike Hume, or Mill, or Comte, he believed that experimental science must be interpreted as establishing that phenomena are the effects of causes which are not themselves directly experienced, and that such an interpretation is legitimate even though the effects which we experience do not resemble their causes. We must now attempt to state what sort of justification Helmholtz was able to offer for his view.

We may start from a point which would not have been challenged by Hume, by Mill, or by Comte: Helmholtz's insistence that knowledge does not consist in an accumulation of observations, or facts, but in the discovery of regularities, or laws, within experience. Phrasing this in terms of experimental science, Helmholtz said:

Isolated facts and experiments have in themselves no value, however great their number may be. They only become valuable from a theoretical or practical point of view when they make us acquainted with the law of a series of uniformly recurring phenomena, or, it may be, only give a negative result showing an incompleteness in our knowledge of such a law, till then held to be perfect.\textsuperscript{24}

At this point Helmholtz took what was the decisive step in his theory of scientific method: he held that those systematizations of facts which are to be considered as laws of nature can be distinguished from systematizations which are imposed upon facts by our own interests, speculative tendencies, or needs. As examples of arbitrary and subjective systematizations he mentioned the Linnean system of classification, as well as the arrangement of materials in an encyclopedia.\textsuperscript{25} The difference between such systematizations and the procedures of science was that in
the first cases the orderliness depended upon the principle which was used to construct the system, whereas in science, Helmholtz held, the order is not imposed upon the data, but must be discovered through careful, systematic examinations of the conditions under which phenomena recur. This distinction was formulated by him in the following crucial paragraphs:

A law of nature . . . is not a mere logical conception that we have adopted as a kind of memoria technica to enable us to more readily remember facts. We of the present day have already sufficient insight to know that the laws of nature are not things which we can evolve by any speculative method. On the contrary, we have to discover them in the facts; we have to test them by repeated observation or experiment, in constantly new cases, under ever-varying circumstances; and in proportion as they hold good under a constantly increasing change of conditions, in a constantly increasing number of cases and with greater delicacy in the means of observation, does our confidence in their trustworthiness rise.

Thus the laws of nature occupy the position of a power with which we are not familiar, not to be arbitrarily selected and determined in our minds, as one might devise various systems of animals and plants one after another, so long as the only object is classification. Before we can say that our knowledge of any one law of nature is complete, we must see that it holds good without exception, and make this test of its correctness. If we can be assured that the conditions under which the law operates have presented themselves, the result must ensue without arbitrariness, without choice, without our cooperation, and from the very necessity which regulates the things of the external world as well as our perception. The law then takes the form of an objective power, and for that reason we call it force. 26

The conception of “force” in which this argument eventuates is obviously not the same conception as that which Hume and others have criticized, for Helmholtz is not claiming that he sees, or otherwise experiences, transfer of power between any observed phenomena. That to which he is appealing is an experienced difference between those cases in which we find that we can arrange observations in any order we may choose, in which we can manufacture new data or obliterate others, etc., and, on the other hand, cases in which we find that we are not able to do so. Thus, that to which he is appealing is similar to that to which Kant appealed in his analysis of causation: the distinction between an objective order of sequence and one which is under the control of the subject. In other words, what Helmholtz is taking to be a sign of force is a resistance or recalcitrance in the sequences which are to be observed among phenomena; he is not assuming that he directly observes one phenomenon offering resistance to another, nor offering resistance to him. The only manner in which he knows of “objective power” or “force” is through the degree of regularity which is to be found in relations among phenomena: he never claims to know it “in-itself.”

We are now in a position to understand the next step in Helmholtz’s analysis: he takes such underlying and unexperienced forces to be causal necessities. Once again we may note that he is not claiming that he directly experiences a relationship of cause and effect: causes are not experienced, but are what underlie those regularities which we discover in phenomena, which are universal and do not fall under the control of our wills.
Helmholtz summarizes this entire theory of science in one brief paragraph which we are now in a better position to understand:

Our desire to comprehend natural phenomena, in other words, to ascertain their laws, thus takes another form of expression—that is we have to seek out the forces which are the causes of the phenomena. The conformity to law in nature must be conceived as a causal connection the moment we recognize that it is independent of our thought and will.

In this paragraph, seen against the background of the foregoing discussion, the following points may be singled out for attention: (1) The aim of science is that of comprehending natural phenomena, not merely accumulating observations and classifying them. (2) This involves formulating laws concerning observable regularities which do not admit of exceptions. (3) The fact that these regularities are not malleable by our thought or will is what leads us to characterize them as objective powers or forces in nature. (4) Such forces are what we refer to as the causes upon which phenomena depend. However, there is a final point which is not explicitly stated in this paragraph, but which must be stressed, for it provides the basic philosophic postulate of Helmholtz’s whole theory of science: (5) To relate a natural phenomenon to a law of nature is to comprehend it: there is no further, more ultimate form of understanding than that which scientific laws provide. Thus, we have no secret access to the powers of nature; we know them only through their observable effects.

Helmholtz’s acceptance of this final proposition might be thought to render nugatory all of his claims regarding “the forces of nature,” which constitute the unobservable causes of observed effects; knowledge would seem to be reduced to a discovery of correlations among the immediately given presentations of the senses. However, this would involve attributing to Helmholtz a position diametrically opposed to that which he did in fact accept. He held that, in order to decide what knowledge we can obtain by means of the presentations of the senses, we must rely upon physics and physiology. Furthermore, he regarded the laws of these sciences as being concerned with relationships which are not directly presented in sense-experience, but can only be established by experimental means. To fail to use such inferences would be to continue to assume that traditional philosophic modes of analysis, which he believed to have been sterile, should take precedence over the methods of science. On Helmholtz’s view, the sciences themselves were now in a position to examine the reliability of our senses, and thus formulate an adequate theory of cognition. His conviction that such was the case rested on his belief that, through the research in which he and others were participating, the sciences were beginning to be able to formulate an interlocking system of physical, physiological, and psychological laws, which would be able to establish interconnections between processes in the external world, the sensations correlated with them, and the perceptions to which such sensations, on the basis of past experience, give rise. On the basis of a knowledge of these interconnections, it would no longer be epistemologically significant that we should have to admit that our sensations are not images of the external world, but only signs of
relationships which obtain within it, and between it and us. Since these signs are not arbitrary, or in any way imposed upon experience by us, since on the contrary they represent the necessary ways in which our organs function, there is no reason to describe the world of our experience as "false." From both a practical and a theoretical point of view, the system of relationships which we can discover within experience is in every way reliable, and is to be denominated as knowledge.

Were one to claim that we still need to ask what lies behind such a system of relationships and is accountable for it, one would be raising metaphysical questions which cannot possibly be given a scientific answer. In response to such questions one would not only have to answer "ignoramus" but "ignorabimus." However, for Helmholtz as for DuBois-Reymond, the tasks of science were sufficiently broad, including all natural phenomena, whether physical or mental, so that the limits of verifiable knowledge would presumably never be reached. To give up the search for answers to unanswerable questions would not only be to free ourselves from unnecessary burdens, but it would open the way for considering those questions to which answers can be found. Among such questions there are not only those which concern the science of physics, but those which refer to organic phenomena and to the phenomena of mind. Once metaphysical dogmas are cleared away, the latter questions, too, can be answered by methods appropriate to science, and a unified system of scientific laws can be expected to result.

It was to the advancement of this task that Helmholtz's own prodigious scientific researches had been directed, and it was this ideal which he sought to elucidate and to justify through his theory of knowledge.

2. HERBERT SPENCER: THE LIMITS OF THE KNOWABLE

In its original form, Spencer's Principles of Psychology, which first appeared in 1855, had a quite different orientation from its radically revised second edition, the first volume of which appeared in 1870, the second volume being issued in installments which were completed in 1872. In the fifteen-year interval, Spencer had formulated his conception of a system of Synthetic Philosophy, and had published First Principles and the Principles of Biology. It was therefore natural that the second edition should have emphasized the place of psychology in the system of the sciences, and should have been concerned with applying the universal law of natural phenomena to psychological processes. Although we are not here concerned with this systematic elaboration of Spencer's views, in attempting to understand his theory of the scope and the limits of human understanding we cannot rely upon the unsystematic organization of the first edition, with which Spencer himself was dissatisfied. Fortunately, Spencer was able to include almost all of the materials of the first edition, which was oriented toward problems of cognition, within the systematic framework of the second edition, providing a clearly articulated theory of knowledge in which a deterministic world-view can presumably be reconciled with a positivistic rejection of metaphysics. In this
respect, as we shall see, the conclusions of Helmholtz and Spencer were essentially similar, in spite of the great differences between their methods of inquiry.

Even in the first edition of the *Principles of Psychology*, Spencer connected the fundamental characteristics of mental life with what he took to be the essential attribute of life-processes: that, in living things, there is "the continuous adjustment of internal relations to external relations." 33 In the first edition, however, attention was not devoted to the nature of the nervous system; it was only later that Spencer came to recognize it as providing the means by which there could be a continuous adjustment between psychological processes and changes in the environment. In the second edition of the *Principles of Psychology* his point of departure therefore became a physiological consideration of the nature and functioning of the nervous system. In this physiological analysis, Spencer identified afferent stimuli with molecular motions, insisting that physiological accounts should rigorously exclude all reference to consciousness. 34 These motions were not to be identified with sensations, for the latter are "feelings," that is, conscious states. If, then, there were to be a science of psychology, there must first be a science which would deal with the relations between nervous stimulation and conscious states: in the absence of such a science one would either be confined to physiology, not dealing with consciousness at all, or one would be at a loss to show how the relations within consciousness were correlated with changes in the environment. The intermediary science was termed "aestho-physiology" by Spencer; its aim was to collate the objective phenomena in the nervous system with the data of consciousness, which are known to us only through introspection. 35

While Spencer's discussion of aestho-physiology is at some points very general and rather obvious, dealing with correlations between our ability to experience various sensations and the fact that we possess a certain type of nervous system, he also attempted to formulate some concrete principles of correlation between changes in experience and measurable changes in the excitation of the nerves. For example, he suggested a correlation between the after-effects of the stimulation of a nerve and the after-effects to be found in sensation; he also suggested that there are quantitative correlations between the strength of nerve-impulses and the degree of feeling which we experience. 36 Thus, what Spencer termed aestho-physiology dealt with many of the conventional problems of psychophysics. In addition, he believed that its findings applied not merely to sensations, but to the other large class of "feelings" designated as "the emotions." 37 In all cases, aestho-physiology had the same task: to correlate the data of consciousness with physiological reactions, not attempting to interpret either in terms of the other but attempting to depict whatever systematic connections existed between them. Spencer described this function in the following terms:

Aestho-physiology has a position that is entirely unique. It belongs neither to the objective world nor the subjective world; but taking a term from each, occupies itself with the correlation of the two. It may with as much propriety be included in the domain of physical science as in the domain of psychical science; and must be left where it stands, as the link between them. 38
Since Spencer’s time it has become customary to include within the province of psychology the inquiries which he assigned to aestho-physiology. Spencer himself did not do so, because his conception of psychology was of a very special sort. Since he wished to relate psychology to what he regarded as the universal nature of living things, he emphasized the adjustment of internal relations to external relations, not the relations between physiological states and consciousness. Thus he was interested in correlating connections between feelings with connections existing between phenomena in the external environment. Aestho-physiology, which connected feelings with physiological processes within the organism was therefore dealing with what was only an intermediary link: its existence as a science was a precondition of there being a science of psychology, but it did not belong within psychology itself.

The task of psychology was, then, that of correlating two distinct types of proposition: one type would assert a connection between two events in the external world, the other would assert a connection between two sensations or other subjective phenomena. Spencer said:

[A psychological proposition] is not the connection between the internal phenomena, nor is it the connection between the external phenomena; but it is the connection between these two connections. A psychological proposition is necessarily compounded of two propositions, of which one concerns the subject and the other concerns the object; and cannot be expressed without the four terms which these two propositions imply. The distinction may best be explained by symbols. Suppose that A and B are two related manifestations in the environment—say the colour and taste of a fruit; then, so long as we contemplate their relation by itself, or as associated with other external phenomena, we are occupied with physical science. Now suppose that a and b are the sensations produced in the organism by this peculiar light which the fruit reflects, and by the chemical action of its juice on the palate; then, so long as we study the action of the light on the retina and optic centres, and consider how the juice sets up in other centres a change known as sweetness, we are occupied with facts belonging to the sciences of Physiology and Aestho-physiology. But we pass into the domain of Psychology the moment we inquire how there comes to exist within the organism a relation between a and b that in some way or other corresponds to the relation between A and B. Psychology is exclusively concerned with this connection between (AB) and (ab)—has to investigate its nature, its origin, its meaning.39

Since he conceived of the task of psychology in this way, Spencer’s psychological system consisted in developing the theory of associations in a manner that extended to all feelings, whether simple or complex, and of then accounting for how such associations are correlated with connections between phenomena in the external world. His theory of associations added little that was new to the associationism of his time; what was new was his hypothesis of the inherited effects of past associations, so that in the history of the race—and not merely in the history of each individual—more and more complex and reliable associations came to be formed. It is not with this clearly untenable psychological system that we must concern ourselves; it is rather to the characteristic nature of its epistemological implications that I wish to direct attention.

In this connection, the first point to be noted is that Spencer, like Helmholtz,
denied that we have any right to assume that there is a qualitative similarity between our sensations and their causes in the external world. Helmholtz’s argument in this respect had taken the doctrine of specific nerve energies as its point of departure; Spencer’s basic position derived from a contrast between the characteristics of molecular motions in the nerves and the qualities of which we are directly aware in experiencing colors, sounds, shapes, odors, etc. In discussing aesthophysics, Spencer held that, while we are bound to acknowledge that feelings are always correlated with nerve impulses so that the two can only be held to be “the subjective and objective faces of the same thing,” yet we are unable to comprehend their relationship to one another: the qualities of our sensations seem utterly different from the molecular motions, or “nerve shocks,” which they accompany. Therefore, since nerve action serves as the necessary intermediating link between the sensations we experience and the external environment, the disparity between the two sides of the aesthophysical relationship precludes us from regarding sensations as being qualitatively similar to what exists independently of us.

In addition to this basic fact, Spencer’s discussion of aesthophysics pointed out another reason why we cannot identify what we experience with what exists independently of experience. Although he held that there is a correspondence between the strength of our feelings and the strength of the nerve impulses which underlie them, he denied that there is a one-to-one correspondence between the strength of these nerve impulses and their external exciting causes. As he pointed out, prior stimulation often tends to diminish later reactions to stimuli of equal strength; therefore, a strict correlation between nerve impulses and feelings entails that there is an actual disparity between feelings and events in the external world.41

These arguments, which were drawn directly from aesthophysics, were not those upon which Spencer chiefly relied when attempting to show that the sensations which we experience are not similar to what exists independently of us. Rather, he cited more traditional forms of epistemological arguments to show that there are variations in the ways in which the organs of different types of organisms react to external stimuli; furthermore, he pointed out that in the case of each individual our sense organs differ in their responsiveness to stimuli, depending upon their sensitivity and upon their condition at any particular time. On the basis of such arguments, Spencer held that it is entirely mistaken to suppose that our sensory experience directly mirrors the qualities of objects which are external to and independent of us. Furthermore, he argued that not only the content of specific sensations was relative to the nature and condition of our sense organs, but that the relationships which we experience among sensations are subject to the same type of relativity. Thus, even the spatial and temporal relations which we experience, and the differences which we can discriminate with respect to sets of feelings, are not to be identified with sets of relationships which exist independently of us. These arguments, which Spencer mobilized in chapters entitled “The Relativity of Feelings” and “The Relativity of Relations between Feelings,” led him to formulate a general proposition which he claimed was a truth “familiar
to all students of Psychology,” that “though internal feeling habitually depends upon external agent, yet there is no likeness between them either in kind or degree.”

This is, of course, similar to the conclusion reached by Helmholtz. However, unlike Helmholtz, Spencer was primarily a philosopher. He felt obligated to offer a defense of epistemological realism against the attacks which could be expected to be leveled against him by those who might claim that under these conditions it was illegitimate to defend realism at all. In both the first and the second editions of his Principles of Psychology, he argued against Berkeley and Hume, attempting to show that, if one were to establish the position that our sensations do actually depend upon the nature and conditions of our sense organs, and if one set out to show that they cannot therefore be interpreted as being identical with what exists in the external world, one could only do so on the basis of realistic assumptions. In short, it was Spencer’s claim that interpretations of sense-perception which presume to establish subjectivism are self-refuting, since arguments designed to establish the principle that our sensations are subjective phenomena always presuppose realistic assumptions: if realism is false, we cannot in fact establish any disparities between what we directly experience and what, in naive experience, we regard as existing independently of us.

The question, of course, immediately arises as to what form of realism Spencer believed to be tenable, and we find that it was a realism which closely resembled the position that Helmholtz had reached. Spencer designated this position as “Transfigured Realism,” characterizing it as “one which simply asserts objective existence as separate from and independent of subjective existence. But it affirms neither that any one mode of this objective existence is in reality that which it seems, nor that the connexions among its modes are objectively what they seem.” Nevertheless, there was one form of correspondence between subjective and objective existence which, Spencer believed, could be affirmed, and that was what may best be regarded as an isomorphism between the set of systematic relationships within experience and the set of relationships existing independently of us. Spencer illustrated this form of correspondence by a diagram of a cube and its perspectival projection on a cylinder. The shape of the surfaces, and the relationships among sides and angles, all have a different form in the projection from that which characterizes their relationships in the cube, but there is a systematic connection among them which corresponds to the systematic connections existing in the object itself. Thus, on Spencer’s view, our sensations and the directly experienced relations among these sensations, cannot in any case be assumed to be images of the nature and the relationships of independently existing objects: to believe the contrary would be to disregard what physics, physiology, and aesthophysiology establish concerning the nature of external objects and the forms of our reactions to them. On the other hand, to deny a systematic connection between what occurs within consciousness and what occurs in the physical world would be to deny the accumulated evidence of the regularity of nature which these same sciences provide. Spencer termed this interpretation of sense experience “transfigured realism” and he held it to be the only sound alternative to that
"crude realism" which was incompatible with a knowledge of science. He believed that, at the same time, it could escape the incoherence of scepticism which assumed the existence of an independent, external world even when it was arguing against our right to believe in such a world.

It might seem inconsistent for Spencer to have held a position which he himself designated as a form of realism, and yet refer to reality as being "the Unknowable." However, we have already seen that a comparable position was characteristic of both DuBois-Reymond and of Helmholtz; in explicating Spencer's view, we shall once again find that he, like them, showed an extreme degree of confidence in scientific knowledge, although he combined that confidence with asseverations concerning the fact that all human knowledge has outer limits which it cannot in any case transcend.

Spencer, like Helmholtz, regarded his realism as having been established on scientific grounds. To be sure, he recognized that it constituted a specifically philosophic position, but it was a position characteristic of a positive philosophy, and differed entirely from the positions of those who were to be designated as "metaphysicians." According to the Kantian heritage which Helmholtz and Spencer shared, metaphysics involved the attempt to form conceptions of reality which transcended the bounds of all possible experience, whereas the sciences were taken to be formulations of systematic connections to be found within experience. Thus, for Helmholtz and Spencer, there could be sciences of matter and of mind, and of the relationships which exist between data of consciousness and changes which occur within the organism; however, there was no way in which one could formulate any conception of what "Matter" or "Energy" is in itself, or what "Mind" is in itself, or whether one is merely a product or appearance of the other.

For Spencer, all knowledge depended upon observation and proceeded by assimilating particular facts into wider and ever wider generalizations. Basically, of course, all of the concepts used in such generalizations ultimately depend upon sense-experience, but he held that it was possible and also necessary to extend these concepts beyond what was originally presented in that experience. We form what he referred to as "symbolic conceptions," as when, for example, we combine our image of an object of spherical shape with the experience of seeing ships sailing over the horizon, and come to conceive of the earth as a sphere. This process of forming symbolic conceptions involves both a simplification of what is originally given in sense perception and an extension of the given to what has not been directly given at all. Spencer regarded this as a wholly legitimate process, without which we could form no generalizations and could discover no general laws. However, symbolic conceptions are only legitimate when it is possible to bring them back into touch with observations, either through direct sense-perception or through showing that the predictions which they enable us to make are actually fulfilled.

Using this basic theory of knowledge as a touchstone, we can see why Spencer believed that his "transfigured realism" could be regarded as scientifically warranted, whereas any attempt to make statements concerning what reality is in-
itself necessarily transcends the limits of knowledge. His epistemological realism could be regarded as having been originally suggested by everyday experience, where our ability to receive impressions rests on the unimpaired functioning of our sense-organs; where that which we experience often varies with the conditions under which we experience it; and where it becomes obvious that different persons experience what we take to be the same object in dissimilar ways. The science of physiology translates these crude generalizations concerning the functioning of our sense-organs into terms of molecular motions in the nervous system; physics and chemistry, along with physiology, serve to relate these nerve impulses to what occurs in the external world. Aestho-physiology provides correlations between sensory content and nerve impulses. It proceeds from an analysis of the individual sense-modalities to wider generalizations concerning the ways in which all sensory experience is correlated with appropriate changes in the nervous system. Finally, psychology, which concerns itself with our complex mental processes, shows how the linkage among our thoughts corresponds with linkages occurring in the external world and accounts for this correspondence in what Spencer took to be a scientifically satisfactory way: through the theory of a biological inheritance of the effects of past experience.

In all of this argument, Spencer would say, he had not left the firm ground of confirmed observations: what are admittedly symbolic conceptions (such as molecular motions in the nerves, or correlations between the stimulation of the retina by light and sensations of sight) are conceptions which are confirmed by the predictions which they permit us to make. Science would be transcended and metaphysics would set in if one tried to form any conception of how motions in the nerves "produce" sensations, or how complex associations of ideas can lead to those efferent nerve-impulses which eventuate in action. To attempt to go behind the verifiable correlations between these utterly different types of concept would be to introduce notions which it is not in any way possible to verify within experience. Thus, Spencer's doctrine of when symbolic conceptions are legitimate, and when they are not, provided him with a way of avoiding traditional metaphysical issues concerning the mind-body relationship, and at the same time allowed him to claim that epistemological conclusions, like all other warranted philosophical conclusions, follow directly from the systematic study of relationships among the data of experience. That there was one widest generalization which included all facts, one fundamental law of nature, Spencer had no doubt: this law of developmental change could, he believed, be established through a synthesis of the sciences.50 It was only with respect to the traditional questions raised not by scientists but by metaphysicians that he, like DuBois-Reymond and Helmholtz, would have said "ignoramus, ignorabimus."

3. Ernst Mach and the Economy of Thought

In moving from the type of position accepted by both Helmholtz and Spencer to that accepted by Mach, we encounter a new interpretation of the limits which
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are to be assigned to human thought. It will be recalled that Helmholtz and Spencer denied that our experience directly mirrors what exists in nature independently of us; however, they both held that the relationships which we gradually come to find within experience can be regarded as corresponding to relationships which characterize nature itself. Both assumed that as the sciences advance, and all facets of experience are more carefully investigated, this correspondence becomes more and more reliable; in this sense it may be said they held that truth is to be construed in terms of a correspondence, i.e., a correspondence between the systematic connection among our ideas and a set of relationships existing in nature itself.\textsuperscript{51} This assumes, of course, that the relationships which we find among experienced entities when we follow the methods used in empirical enquiry are not artifacts created by those methods, but are controlled by relationships existing independently of us. It was precisely this assumption that came to be challenged with increasing frequency by philosophers of science. It is with one such challenge, that of Ernst Mach, that we shall now be primarily concerned.\textsuperscript{52}

Unlike Helmholtz and Spencer, Mach demanded that we confine our assertions about nature and about ourselves to statements which refer to elements given within experience, avoiding all assumptions concerning that upon which experience depends. In interpreting this injunction, one must note what it was that Mach regarded as being directly given in experience. On his view, that by which we are confronted is not a world of objects, and we do not experience ourselves as something different from these objects, standing in various relations to them; rather, he took experience to be constituted by free-floating "elements," that is, by data which do not entail the existence of anything else, but are simply there, within experience. Furthermore, it was Mach's view that the manner in which these elements came to be organized, forming our conceptions of the world, is not determined by characteristics intrinsic to the elements themselves; rather, ways of organizing them develop during the course of human experience according to the interests or purposes which take shape within us. On this assumption, the question of what constitutes truth must be answered by offering some criterion by means of which we can discriminate better from worse principles of organization among the elements making up our experience. Mach held that the sciences, correctly interpreted, furnish the clearest example of a satisfactory criterion, and on this basis he formulated his theory of "the economical nature of thought." It is in connection with this doctrine that his views differ markedly from those of earlier positivists, and that they are most clearly related to other tendencies in later nineteenth-century philosophy; for that reason it will be helpful to see how he came to develop his position regarding the economy of thought.

If we consult Mach's various sketches of his intellectual development we can trace the main stages in the process leading up to his acceptance of the view that our conceptions of the world rest, in the last analysis, on the principle of the economy of thought.\textsuperscript{53} At the age of fifteen he had read Kant's \textit{Prolegomena to any Future Metaphysic}, and it had made a profound impression upon him; however quite suddenly, two or three years later, he came to believe that the Kantian
assumption of things-in-themselves was an unnecessary and empty assumption, and at this stage he moved toward an acceptance of Berkeley's idealism. However, he tells us that an interest in the physiology of sense-perception, as well as the study of Herbart, soon led him to abandon Berkeley's position for one more nearly akin to that of Hume, although he did not yet know Hume's work. This shift, we may conjecture, involved the abandonment of the notion of a substantial self, or ego; a step which was in line with his previous abandonment of the conception that there is some Kantian "Unknown-X" behind the sensory qualities which we experience. This extension of his position in the direction of a pure subjectivism presumably took place prior to his receiving his doctorate in 1860.

Between that time and 1864, when he received a professorship at Graz, two independent and highly important influences helped to develop his later philosophy of science. On the one hand, in lectures concerning physical theory which he gave as a Privat-Dozent in Vienna, beginning in 1861, he became convinced that ideals of simplicity in explanation had been of the greatest importance to Copernicus, Galileo, and Newton; this, he tells us, was one factor which prepared the way for the later development of his theory of the economy of thought.

Less obviously connected, but conceivably of even greater later importance, was Mach's concern with the problems of psychophysics after the appearance of Fechner's *Elemente der Psychophysik* in 1860. He had already been interested in allied problems, studying the Doppler-effect in relation to sound and colors, and for a time he increasingly occupied himself with psychophysics. In fact, he delivered a broad-ranging series of lectures concerning these problems, and although he later denigrated their value, we may note that in the course of them he criticized Helmholtz's position from a point of view which, apparently, he never abandoned.

If I read him aright, what Mach rejected was Helmholtz's view that, in general (i.e., under normal circumstances), differences among the qualities of our sensations represent differences among the causes of the nerve impulses which are connected with these sensations—a doctrine which would allow for the type of correspondence theory of truth which I have attributed to both Helmholtz and Spencer. In opposition to this assumption, Mach argued that, since different antecedents might give rise to similar nerve impulses, the qualitative distinctions among sensations should be correlated with ascertainable changes in the sense organs, not with the postulated *causes* of these changes.

From this point on, as his various publications show, Mach became more interested in the physiological bases of sensations in the sensing organs; in these investigations, his method consisted in directly correlating relationships between physiological stimulation and sensory experience, rather than tracing a physiological chain of causes that could be said to have a particular sensory element as its ultimate effect. This, he felt, permitted him to unify all of the data relevant to psychophysics in a single continuum, whether these data were usually classified as belonging within the province of physics, or psychology, or physiology. For example, the events with which physicists deal when they deal with light emanating from a particular source would be directly correlated with how the eye reacts to such light, and since Mach was correlating sensations with events occurring on
the sensing organ, he could move easily back and forth between the sensation "yellow," a physical source of yellow light, and the reaction of the eye to such light. Thus, psychophysics relied on objective correlations, not on a chain of causal links in which one would first be tracing a series of physical events, then a series of physiological events, and finally mention a specifically psychological event: "this sensation of yellow." It was this conception of a unified, objective science which was the position which Mach later developed at length in his *Analysis of Sensations*.

While there is no evidence that, at the time, he had already formulated his position in the full-fledged epistemological fashion which characterized that later work, the method which he had developed for dealing with psychophysical problems can be considered as having paved the way for an acceptance of the principle of the economy of thought: it rid psychophysics of the mind-body problem which had provided a background for it in Fechner's work, and, even more importantly, it rid psychophysics of hypotheses involving unobserved causal relationships, such as those which had been assumed by Helmholtz.

While Mach did not publish any statement concerning the principle of the economy of thought until his essay on *The History of the Principle of the Conservation of Energy* (1872), the idea itself took shape for him during this earlier period, while he was still at Graz (1864-67). As he tells us, it had two sources: on the one hand, it was suggested by discussions with his colleague and friend, Emanuel Hermann, who was an economist; on the other hand, it derived from a Darwinian-inspired view that there is a struggle for survival among scientific conceptions. As Mach himself notes in this connection, originally these were entirely independent ideas. The ideal of simplicity in scientific explanations, which had already impressed him, became associated with what appear to have been Hermann's views, developing into Mach's contention that scientific laws are simply marvelously economical means for describing observed phenomena. On the other hand, what he drew from the Darwinian concept of a struggle for survival was a way of interpreting the history of thought. As he tells us in the same passage, he used this notion in his University lecturing at Graz. In one popular lecture on the velocity of light, dating from this period, he expressed his Darwinian position in the following way:

> It will now perhaps be clear to you that new thoughts do not spring up suddenly. Thoughts need their time to ripen, grow, and develop in, like every natural product; for man with his thoughts, is also a part of nature.

> Slowly, gradually, and laboriously one thought is transformed into a different thought, as in all likelihood one animal species is gradually transformed into new species. Many ideas arise simultaneously. They fight the battle for existence not differently than do the Ichthyosaurus, the Brahman, and the horse.

> A few remain to spread rapidly over all fields of knowledge, to be redeveloped, to be again split up, to begin again the struggle from the start. As many animal species long since conquered, the relics of ages past, still live in remote regions where their enemies cannot reach them, so also we find conquered ideas still living on in the minds of many men. Whoever will look carefully into his own soul will acknowledge that thoughts battle as obstinately for existence as animals.
While this position is not incompatible with holding that when we develop a scientific law we are simply finding a shorthand way of describing experience, the connection between the two views is not immediately evident. It is to establishing their linkage that we must now turn.

Mach himself gives us the clue as to their connection when he speaks of his view as a biological economical view of thought, holding that all thought serves adaptive purposes. In two popular lectures entitled "The Economical Nature of Physical Inquiry" and "On Transformation and Adaptation in Scientific Thought," which date from 1882 and 1883, as well as in his Science of Mechanics, which was published in the latter year, he held that the fundamental characteristic of the mind is that it organizes experience in ways that prove to be useful. In fact, in the former essay, Mach goes so far as to praise Schopenhauer's view that the will creates the intellect for its own purposes. Although this way of speaking of "will" and "intellect" is not compatible with Mach's more mature views, as developed in his Analysis of Sensations and elsewhere, from this point on he stressed the fact that thought functions as a means of adaptation by organizing experience in whatever ways make it most manageable.

One form of organizing the "elements" given in experience is, of course, to regard them as clustered into more or less permanent objects, among which one's own body is one such object. The importance of the conception of permanent objects, to which changes can be related, was expressed by Mach in his Science of Mechanics when he held:

All ideas of conservation, like the notion of substance, have a solid foundation in the economy of thought. A mere unrelated change, without fixed point of support, or reference, is not comprehensible, not mentally reconstructible (p. 504).

It was on this basis that he accounted for the fact that, in ordinary experience, what we are interested in are objects, viewed as permanent, and this relative permanency of clusters of elements becomes more stable through our useful habit of designating them by single names, and grouping them together in single thoughts. According to Mach, such supposedly permanent entities, whether they be "bodies" or "ego," are "only make-shifts, designed for provisional orientation and for definite practical ends." This organization of elements into our conception of permanent things naturally involves viewing the elements in terms of spatial relationships; in order to account for the particular spatial organization they display, Mach again appealed to biological functions, holding that our perceptual space is organized to fulfil the adaptive needs of the organism.

If one asks how the individual human being has time to acquire these deep-seated and lasting modes of organizing experience in the short span of his earliest years, Mach answers in the same vein as did Spencer: all of the basic assumptions which appear as "instinctive" to us, represent the funded experience of the race, "bequeathed to us as an heirloom by our forefathers." In this connection Mach said:
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Such primitive acts of knowledge constitute to-day the solidest foundation of scientific thought. Our instinctive knowledge, as we shall briefly call it, by virtue of the conviction that we have consciously and intentionally contributed nothing to its formation, confronts us with an authority and logical power which consciously acquired knowledge even from familiar sources and of easily tested fallibility can never possess. All so-called axioms are such instinctive knowledge.⁶⁹

Nevertheless, in spite of the compelling character of such instinctive knowledge, and in spite of its undoubted usefulness for the ordinary adaptive purposes of life, Mach did not place total reliance upon it. In fact, from the point of view of the sciences, it was a hindrance and not a help. In the *Analysis of Sensations* and in *Erkenntnis und Irrtum*, as well as elsewhere, he argued against accepting the hidden metaphysical axioms of common-sense when one is engaged in constructing an adequate and unified system of scientific knowledge. For example, he felt it imperative for scientific purposes to reject our common-sense contrasts between self and object, or between particular sensations and permanent things, both of which he recognized to be of definite utility within everyday experience; however, from the point of view of advanced scientific investigations, both were prejudices and definitely disadvantageous.⁷⁰ What was at stake in scientific investigation was not the direct adaptation of the human organism to the environment world, but the successful unification of experience within a single economic system which permits us to codify, recall, and anticipate experience. Only by possessing such a system can we overcome the limitations of human memory, and acquire a stock of knowledge adequate for all of our purposes. The methods developed by the sciences, in particular their ability to summarize regularities in experience by means of mathematically formulated laws, provided the solution to this problem. It was in this context that Mach remarked that science itself could be regarded as a problem concerning *minima*: how one can achieve the most complete summarization of facts with the least possible expenditure of thought.⁷¹ This economical function of science was what led to its biological usefulness. Thus, in spite of the fact that it contravened the powerful, instinctive metaphysics of common-sense, science performed important adaptive functions, permitting us to recall and anticipate experience in far more satisfactory ways than our everyday modes of thought permit us to do. Thus, Mach interpreted science in an ultimately biological way:

The biological task of science is to provide the fully developed human individual with as perfect a means of orientating himself as possible. No other scientific ideal can be realized, and any other must be meaningless.⁷²

It is at this point that we note how sharply Mach's thought diverged from the realistic assumptions of Helmholtz and Spencer, for while each of them also regarded human thought as performing an adaptive function, neither identified the goal of science with the performance of that function. Rather, each regarded science as capable of deciphering relationships in nature, and of finding causal
laws to explain the existence of these connections among phenomena. For Mach, however, the connections among phenomena which are described by the sciences are consequences of the theories through which we organize these phenomena, rather than reflecting independently existing facts. Thus, for example, he said:

A theory, indeed, always puts in the place of a fact something different, something more simple, which is qualified to represent it in some certain aspects, but for the very reason that it is different does not represent it in other aspects.

Only in rare cases will the resemblance between a fact and its theoretical conception extend further than we ourselves postulate. As a general rule we have every reason to distinguish sharply between our theoretical conceptions of phenomena and that which we observe. The former must be regarded merely as auxiliary instruments that have been created for a definite purpose and which possess permanent value only with respect to that purpose. And in even more extreme form, and in contrast to the beliefs of DuBois-Reymond, Helmholtz, and Spencer regarding the uniformity of nature, Mach explicitly said:

Suppose we were to attribute to nature the property of producing like effects in like circumstances; just these like circumstances we should not know how to find. Nature exists once only. Our schematic mental imitation alone produces like events. Only in the mind, therefore, does the mutual dependence of certain features exist.

In this respect, Mach’s views departed radically from earlier forms of positivism and merged with the ever-growing stream of philosophers who abandoned the view that through the methods of the sciences we can uncover relationships in nature which exist whether we know them or not, and which are what they are, however we may choose to describe them. From Mach’s point of view, the abandonment of this conception of the sciences was to be welcomed rather than deplored, since it abolished with a single stroke the assumption that human knowledge was necessarily limited in the ways in which DuBois-Reymond, Helmholtz, and Spencer had assumed it to be. Issues as to how consciousness is related to the body, or what accounts for the ways in which matter behaves, were to be regarded as fictitious problems, and they did not therefore place arbitrary limits on how far scientifically organized knowledge could proceed. Thus, from Mach’s point of view, the range of science was indefinitely extended: it could organize the elements of experience in whatever ways proved to be most fruitful in storing up and codifying that experience for the purpose of anticipating and adapting to future events. While this open-endedness has obvious attractions, one may legitimately wonder whether Mach’s theory of the economy of thought does in fact do justice to either the recalcitrance of the ways in which experience presents itself to us, or to the implications which are to be drawn from a biologically oriented theory of the human mind. It is with these questions, among others, that our concluding chapter will be concerned.