

remained in the Greek tradition—he was innocent of the later Orientalizing—he undoubtedly made an original contribution to philosophy. His ethics is a greatly refined analysis of the emotions which refutes the rationalistic position by pointing to its inner inconsistency and its inconsistency with observed facts. He stressed the importance of the will. Although only a few details of his physics can be rediscovered, it is clear that he was intent on explaining things; he was famous for his etiologies, and he carefully distinguished the various causes, assigning first place to teleology. Cosmic sympathy is but one of the factors he invoked in his exegesis of nature. His logical investigations furthered the understanding of syllogistic thinking, which seemed to him validated not by linguistic connections but by implied axioms. In short, his system marks a step forward in the history of Greek rationalism, and this is in accord with Posidonius' belief in the gradual development of knowledge and in the idea of progress, which he, like so many earlier Greek rationalists, upheld.

Posidonius' contributions were, however, not restricted to the field of philosophy proper. He wrote a history of his own time and in it, if not separately, dealt copiously with the rise of civilization, which he claimed began with practical inventions made by philosophers. In the historical process itself he detected the dominance of freedom over circumstance. Several of his books were devoted to natural sciences, such as astronomy and meteorology; he also investigated problems of mathematics and of military tactics. Perhaps the greatest significance of these works lies in the fact that they do not isolate scholarly and scientific research but put it in a philosophical framework. Events are seen as part of the history of the cosmos. Scientific explanations are hypotheses, the correctness and adequacy of which must be judged through philosophical reflection. It was as a philosopher that Posidonius felt impelled to reject the heliocentric theory in favor of the geocentric theory. Although he erred in this respect, he did enforce the idea of the hypothetical character of all scientific knowledge and did restore the unity of the sciences which Hellenistic thought had destroyed.

The stoa of the empire, initially influenced by Posidonius, tended more and more to follow Chrysippus. Thus, the philosopher Posidonius soon lost importance. His scientific writings kept the Greek heritage alive much longer and carried it, through Seneca's *Naturales Quaestiones*, into the Middle Ages. If one judges his achievement and his influence, one cannot compare him with Plato, Aristotle, or Democritus or with Zeno, Epicurus, or Plotinus. It is fair to say, however, that his personality, which he allowed to intrude into his work, makes him one of the most attractive figures among ancient philosophers. He was a man of dignity and not without a sense of irony and humor. He lived the dogma he preached, studying and teaching as well as participating in the political affairs of Rhodes, his adopted city. The variety of his gifts is amazing—his dialectical skill, traced by Galen to his mathematical erudition; the keenness of his powers of observation of men and things, which is especially marked in his reports on the travels that took him throughout almost the whole of the then-known world; and the strength of his analytical ability, along with his love of literature and art.

It was perhaps the universalism of his nature that made it possible for him not only to attempt a new explanation of the universe in all its aspects, doing justice to both man's cognitive and his practical concerns, but also to root human existence—for the last time in antiquity, it seems—in the world of reality without depriving this world of the reign of human reason, which he considered of the same nature as the divine spirit ruling the cosmos.

### Bibliography

The approach of *Quellenforschung* has been criticized, and criticized fairly, by J. F. Dobson, "The Posidonius Myth," in *Classical Quarterly*, Vol. 12 (1918), 179 ff. For Posidonius as a monist see K. Reinhardt, *Poseidonios* (Munich, 1921); see also his *Kosmos und Sympathie* (Munich, 1926) and A. Pauly and G. Wissowa, *Realencyclopädie der classischen Altertumswissenschaft*, Vol. XXII (Stuttgart, 1953), Part I, Cols. 558–826. I. Heinemann, *Poseidonios' metaphysische Schriften*, 2 vols. (Breslau, 1921–1928), considers Posidonius especially in relation to his predecessor Panaerius.

For a reconstruction of Posidonius' philosophy according to the attested fragments see Ludwig Edelstein, "The Philosophical System of Posidonius," in *American Journal of Philology*, Vol. 57 (1936), 286 ff. For the historical fragments see F. Jacoby, *Die Fragmente der griechischen Historiker*, Vol. II, No. 87 (Berlin, 1926). The collection of fragments by I. Bake, *Rhodii Reliquiae Doctrinae* (Leiden, 1810), is antiquated.

LUDWIG EDELSTEIN

**POSITIVISM.** The term "positivism" was used first by Henri, comte de Saint-Simon to designate scientific method and its extension to philosophy. Adopted by Auguste Comte, it came to designate a great philosophical movement which, in the second half of the nineteenth century and the first decades of the twentieth, was powerful in all the countries of the Western world.

The characteristic theses of positivism are that science is the only valid knowledge and facts the only possible objects of knowledge; that philosophy does not possess a method different from science; and that the task of philosophy is to find the general principles common to all the sciences and to use these principles as guides to human conduct and as the basis of social organization. Positivism, consequently, denies the existence or intelligibility of forces or substances that go beyond facts and the laws ascertained by science. It opposes any kind of metaphysics and, in general, any procedure of investigation that is not reducible to scientific method.

The principal philosophical sources of positivism are the works of Francis Bacon, the English empiricists, and the philosophers of the Enlightenment; but the cultural climate that made it possible was that of the eighteenth-century industrial revolution and the grand wave of optimism to which the first successes of industrial technology gave rise. Positivism made this climate into a philosophical program—that is, a universal project for human life. It exalted science without concerning itself (as does contemporary positivism) with the conditions and the limits of the validity of science, and it claimed that not only ethics and politics but also religion would become scientific disciplines. In one direction, this led to an attempt to establish a "positive" religion in place of traditional theological religions.

Through its acceptance of the concept of the infinity of nature and of history and, therefore, of necessary and universal progress, positivism had affinities with the other important nineteenth-century philosophical movement, absolute idealism, and belongs with it in the general range of romanticism.

There are two fundamental kinds of positivism: social positivism, with a professedly practicopolitical character, and evolutionary positivism, with a professedly theoretical character. Both share the general idea of progress, but whereas social positivism deduces progress from a consideration of society and history, evolutionary positivism deduces it from the fields of physics and biology. Comte and John Stuart Mill are the principal representatives of social positivism, and Herbert Spencer of evolutionary positivism. A materialistic or spiritualistic metaphysics is often associated with evolutionary positivism. A third, critical type of positivism, also known as empiriocriticism, should be distinguished from both social and evolutionary positivism. Contemporary forms of positivism—logical positivism and neopositivism—are directly connected with critical positivism.

### SOCIAL POSITIVISM

Social positivism arose in France through the work of Saint-Simon and other socialistic writers (Charles Fourier, Pierre Joseph Proudhon) and in England through that of the utilitarians (Jeremy Bentham and James Mill), who, in turn, considered their work closely associated with that of the great economists Thomas Malthus and David Ricardo. Social positivism sought to promote, through the use of the methods and results of science, a more just social organization. According to Saint-Simon, men now lived in a critical epoch because scientific progress, by destroying theological and metaphysical doctrines, had eliminated the foundation of the social organization of the Middle Ages. A new organic epoch, in which positive philosophy would be the basis of a new system of religion, politics, ethics, and public education, was required. Through this system society would regain its unity and its organization by basing itself on a new spiritual power—that of the scientists—and a new temporal power—that of the industrialists. In his last writing, *The New Christianity* (1825), Saint-Simon considered the new organic epoch to be a return to primitive Christianity.

**Comte.** Saint-Simon's ideas inspired the work of Auguste Comte. The point of departure of Comte's philosophy is his law of the three stages. According to this law, both the general history of humanity and the development of the individual man, as well as that of every branch of human knowledge, passes through three stages: the *theological*, or fictitious, stage in which man represents natural phenomena as products of the direct action of supernatural agents; the *metaphysical* stage, in which the supernatural agents are replaced by abstract forces believed to be capable of generating the observable phenomena; and, finally, the *positive* stage, in which man, refusing to seek the ultimate causes of phenomena, turns exclusively toward discovering the laws of phenomena by observation and reasoning. The positive stage is that of science, whose

fundamental task is to predict phenomena in order to utilize them.

"Science whence comes prediction; prediction whence comes action" is the formula in which Comte epitomized his theory of science. The formula, as Comte himself recognized, expresses exactly Francis Bacon's point of view. The law of the three stages permits the classification of the sciences according to the order in which they entered into the positive phases—an order determined by the degree of simplicity and generality of the phenomena which are the objects of each science as it reaches the positive phase. Thus, according to Comte the following hierarchy constitutes "a necessary and invariable subordination": astronomy, physics, chemistry, biology, and sociology. Mathematics remains outside this order because it is at the basis of all the sciences; psychology, because it is not a science, also remains outside. Psychology should be based on introspective observation. But introspective observation is impossible, because the observed and observing organ would have to be identical. The apex of the hierarchy of sciences is sociology, or social physics, which Comte divided into social statics, or theory of order, and social dynamics, or theory of progress.

Progress is a necessary law of human history: the realization of progress is entrusted not to individuals, who are only the instruments of progress, but to the true subject of history—humanity, conceived as the Great Being in which past, present, and future beings partake. "We always work for our descendants, but under the impulse of our ancestors, from whom derive the elements and procedures of all our operations" (*Politique positive*, Vol. IV, pp. 34–35). Humanity is the continuous and uninterrupted tradition of the human race, and it is the divinity that must replace the God of traditional religions. The wisdom and providence of humanity preside infallibly over the realization of progress. At the end of progress there is sociocracy, a new absolutist social regime based on science and the religion of humanity and directed by a corporation of positivist philosophers. Sociocracy, by limiting liberties, will make impossible any deviation from the fundamental beliefs of the positivistic cult.

In his last work, *Philosophy of Mathematics* (1856), Comte proposed a new kind of religious trinity, the Great Being (humanity), the Great Fetish (the earth), and the Great Way (space). The religious aspect of Comte's philosophy drew a great number of followers and generated the greatest wave of enthusiasm. Pierre Lafitte and Émile Littré in France, Richard Congreve and G. H. Lewes in England were the most philosophical of Comte's first disciples. The influence of Comte's religious thought, however, rapidly exhausted itself, except among small groups of devotees, while his philosophical ideas (the law of the three stages; the conception of science as description and prediction; the theory of progress; and sociology as a positive science) have exercised a lasting influence on science and philosophy.

**Bentham and the Mills.** Comte's English contemporaries, the utilitarians Jeremy Bentham and James Mill, presented with equal force, although more modestly, the fundamental requirement of positivism: that every kind of valid knowledge be included within science. They sought

to establish a science of mind based on facts, as is the science of nature, and tried to make ethics itself, as Bentham used to say, an "exact science." They considered the mind to be an associative mechanism, ruled by precise laws whose constitutive elements are sensations, which were regarded as the ultimate facts of mind. Traditional ethics was substantially a theory of the end of human conduct: It established by a *priori* means what that end was and deduced from it the rules of conduct. Bentham and Mill intended to substitute for traditional ethics a theory of the motives of conduct—that is, of the specific causes of conduct. If it were ascertained what are the motives and the rules that human beings obey, Bentham and Mill believed, it would be possible to direct human conduct in the same way that nature can be controlled by knowing its causal laws.

These principles remained fundamental in later developments of positivism, first in the work of John Stuart Mill, who was influenced by both Saint-Simon and Comte. Mill, like Saint-Simon and Comte, spoke of reorganizing society on new foundations. He rejected, however, the doctrinaire political and religious absolutism of Comte and defended instead the freedom and development of the individual, to whom he considered the social organization subordinate. Mill's classic *Principles of Political Economy* (1848) concluded by determining the limits of governmental intervention in economic affairs—limits required so that there would be in human existence "a sacred fortress safe from the intrusion of any authority."

Mill's *System of Logic* (1843), which is perhaps the most important work of nineteenth-century positivism, contains a fundamental correction of Comte's view of science. Comte had stressed the rational aspect of science and considered its experimental basis, the verification of facts, as merely preparatory to the formulation of laws. He had excluded the notion that once they were formulated, laws could again be subjected to the test of facts and eventually placed in question by "a too detailed investigation," and he had prescribed for scientific investigation a series of limitations to keep it from being transformed into "a vain and at times a seriously disturbing curiosity." Mill's logic, instead, appealed to a radical empiricism and avoided any dogmatizing of scientific results. The very principles of logic, according to Mill, are generalizations of empirical data, and induction is the only method that science has at its disposal. The basis of induction itself, the principle of the uniformity of the laws of nature, is, in turn, an inductive truth, the fruit of many partial generalizations. Prediction is possible in science only on the basis of past experience, which alone furnishes the evidence both for the major premise and for the conclusion of the traditional syllogism. "'All men are mortal' is not the proof that Lord Palmerston is mortal; but our past experience of mortality authorizes us to infer *both* the general truth and particular fact with the same degree of certainty for one and the other" (*System of Logic*, Bk. II, Ch. 3).

Like the other utilitarians, John Stuart Mill held that the human mind has the same structure as natural phenomena and is knowable in the same ways. "If we knew the person thoroughly, and knew all the inducements which are acting upon him, we could foretell his conduct with as much

certainty as we can predict any physical event" (*System of Logic*, Bk. VI, Ch. 2, 2). To make such predictions possible, he held that a new science, *ethology*, was needed to study the laws of the formation of character. Mill placed this science alongside Comtian sociology, to which he attributed the task of discovering the laws of progress that make it possible to predict social events infallibly (*ibid.*, Ch. 10, 3).

Mill held that even religion should be based on experience. Experience, by suggesting that there is a limited and imperfect teleological order in nature, permits belief in a divinity of limited power, a kind of demiurge. Such belief encourages a religion of humanity based upon an altruistic ethics and the "supernatural hopes" of mankind.

**Social positivism in Italy and Germany.** In Italy social positivism had two defenders, Carlo Cattaneo and Giuseppe Ferrari. Both were influenced by the work of Saint-Simon, and both saw him as a continuer of the work of Giambattista Vico, whom they credited with having founded "a science of man in the very heart of humanity."

The German social positivists Ernst Laas, Friedrich Jodl, and Eugen Dühring appealed to Ludwig Feuerbach rather than to Saint-Simon and Comte. But faith in science, in progress based on science, and in a perfect social form to which this progress must lead was the inspiration of all social positivists.

#### EVOLUTIONARY POSITIVISM

Evolutionary positivism shared the faith in progress of social positivism but justified it in a different way. Evolutionary positivism is based not on society or history but on nature, the sphere of physics and biology. Its immediate forerunners were the work of the geologist Charles Lyell and the doctrine of biological evolution. Lyell, in *The Principles of Geology* (1833), demonstrated that the actual state of the earth is the result not of a series of cataclysms (as Cuvier had argued) but rather of the slow, gradual, and imperceptible action of the same causes that are acting before our eyes. The doctrine of evolution triumphed in 1859 with the publication of Charles Darwin's *Origin of Species*, which first presented adequate proofs of biological evolution and formulated the doctrine in a rigorous way. Lyell's and Darwin's doctrines made possible the formulation of the idea of a natural and necessary progress of the whole universe, beginning with a cosmic nebula and, through the uninterrupted development of the inorganic and organic world, continuing into the "super-organic" development of the human and historical world. It is superfluous to note that the scientific theories which furnish the occasion for the rise of the idea of evolutionary positivism do not constitute the elements of a sufficient proof of it, since it is so highly generalized a hypothesis that it seems to be of a metaphysical nature. Darwin himself remained "agnostic" (to use the term created by another biological evolutionist, T. H. Huxley) with respect to all problems that concern the universe in its totality.

**Spencer.** The importance of Herbert Spencer, however, and the lasting influence of his work, depends on his defense of universal progress as a continuous and unilinear evolution from a primitive nebula to the more refined

products of human civilization. Spencer used the term "evolution" in preference to progress in an early programmatic article of 1857, and even then he saw universal progress as modeled on biological evolution. His definition of evolution as "the passage from the homogeneous to the heterogeneous" or from the simple to the complex was suggested by the development of vegetable and animal organisms, whose parts are chemically and biologically indistinct at first but which then differentiate to form diverse tissues and organs. Spencer held that this process can be discovered in all fields of reality and that each of these fields has a specific science whose task is to recognize and clarify its characteristics. Philosophy is (as Comte conceived of it) the most generalized knowledge of the process of evolution. The role of philosophy begins with the widest generalizations of the individual sciences; from these generalizations it seeks to realize a "completely unified" knowledge. However, neither philosophy nor science, according to Spencer, can take the place of religion.

The truth of religion is that "the existence of the world with all that it contains and all that it encompasses is a *mystery* that always needs to be interpreted" (*First Principles*, London, 1862, Par. 14). All religions, however, fail in giving this interpretation; therefore, the sole task of authentic religion is to remind men of the mystery of the ultimate cause. The task of science, on the other hand, is to extend indefinitely the knowledge of phenomena. Like William Hamilton and Henry Mansel, Spencer held that human knowledge is enclosed within the limits of the relative and the conditioned, that is, within the limits of phenomena. Beyond these limits there is the unlimited and unknown force on which all phenomena depend. The unknowability of this force is revealed in the insolubility of certain problems at the limits of philosophy and science, such problems as those concerning the essence of space, of time, of matter, and of energy, the duration of consciousness (whether finite or infinite), and the subject of thought (whether it is the soul or not).

If Comte's religion of humanity had little success among philosophers and scientists, Spencer's agnosticism found many adherents among them, and for a few decades it was a required attitude for intellectuals generally. However, other positivists, like Roberto Ardigò, rejected agnosticism and denied that one could speak of an "unknowable" in an absolute sense. Ardigò, moreover, wanted to redefine the process of evolution by considering it as "a passage from the indistinct to the distinct," referring to psychological experience rather than to biology.

Spencer wrote on many fields of knowledge—biology, sociology, ethics, politics, and education. When he turned his attention to sociology, he attempted to rescue it from the practical and political task that Comte had assigned to it and to consider it as a theoretical discipline whose task is to describe the development of human society to its present state. This change was accepted by such positivist sociologists as John Lubbock, Edward Tylor, Émile Durkheim, and William Graham Sumner, who were strongly influenced by Spencer.

Evolutionary positivism is, in its more rigorous form, as far from materialism as it is from spiritualism. Spencer

affirmed (*ibid.*, Par. 194) that the process of evolution can be interpreted both in terms of matter and movement and in terms of spirituality and consciousness: the Absolute which it manifests can be defined neither as matter nor as mind. Positivism embraces both trends which interpret the concept of evolution materialistically and trends which interpret it spiritualistically. The laws of the conservation of matter discovered by Antoine Lavoisier (1789) and the laws of the conservation of energy implicit in Robert Mayer's discovery of the equivalence of heat and work (1842) were taken as proofs of the hypothesis that a single substance, of which matter and energy are inseparable attributes, is the eternal subject of cosmic evolution and necessarily determines all its characteristics.

**Haeckel and monism.** The German philosopher Ernst Haeckel termed the view that matter and energy are inseparable attributes of one basic substance "monism" and utilized it to combat the dualism that he held was proper to all religious conceptions based on the duality of spirit and matter, of God and the world. Haeckel also found a decisive confirmation of biological evolution and of its necessity in what he termed the "fundamental biogenetic law" of a parallelism between ontogeny, the development of an individual, and phylogeny, the development of the species to which that individual belongs. Monism was accepted by many chemists, biologists, and psychologists and became popular through the diffusion of Haeckel's writings and of such other works as Ludwig Büchner's *Force and Matter* (1855).

Monism also inspired literary and historical criticism. A passage from the introduction to Hippolyte Taine's *History of English Literature* (1863) has remained famous as an expression of this tendency: "Vice and virtue are products just as vitriol and sugar are, and every complex datum is born from the encounter of other simpler data on which it depends."

**Lombroso.** The positive school of penal law, founded by Cesare Lombroso, drew its inspiration from materialistic and especially from deterministic positivism. This school taught that criminal behavior depends on inevitable tendencies which are determined by the organic constitution of the delinquent. The structures of this constitution would be analyzed by a corresponding science—criminal anthropology.

**Wundt.** Evolutionary positivism was also interpreted spiritualistically, notably by Wilhelm Wundt, who sought to substitute "psychophysical parallelism" for materialistic monism. Wundt's doctrine was that mental events do not depend on organic events but constitute a causal series by themselves and correspond point for point to the series of organic events. He made this doctrine the basis of his psychological investigations (Wundt founded the first laboratory of experimental psychology), and for many decades it remained the working hypothesis of experimental psychology. Wundt cultivated, moreover, a "psychology of peoples" which is descriptive sociology, in Spencer's sense. Like Spencer, Wundt intended it to be the study of the evolutionary process that produces institutions, customs, languages, and all the expressions of human society.

**Influence of evolutionary positivism.** Evolutionary positivism has left as a legacy to contemporary philosophy

the idea of a universal, unilinear, continuous, necessary, and necessarily progressive evolution—an idea which forms the background and the explicit or implicit presupposition even of many philosophies which do not recognize their debt to positivism and which, in fact, argue against it. The idea of evolution is fundamental to the philosophies of C. S. Peirce, William James, and John Dewey, as well as to those of George Santayana, Samuel Alexander, and A. N. Whitehead. Some of these philosophers have sought to remove the necessitarian character from the idea of evolution and to include within it an element of chance or freedom (Peirce, James, Dewey) or of novelty and creativity (Henri Bergson, C. Lloyd Morgan). Bergson, who interpreted evolution in terms of consciousness and insisted upon its creative character, explicitly acknowledged his debt to Spencer (*La Pensée et le mouvement*, 3d ed., Paris, 1934, p. 8). It is not without reason that his disciple Édouard Le Roy termed Bergson's doctrine a "new positivism," which means a new spiritualistic interpretation of cosmic evolution.

The vitality and the broad diffusion of the legacy of positivism is no sign of its validity. No scientific discipline is as yet able to adduce any sufficient proof in favor of a unilinear, continuous, and progressive cosmic evolution. In fact, in the very field where the phenomena of evolution have been most closely considered—biology—evolution seems to lack precisely those characteristics that positivism attributes to it.

### CRITICAL POSITIVISM

**Empiriocriticism.** In the last decade of the nineteenth century, positivism took on a more critical form through the work of Ernst Mach and Richard Avenarius. In Germany and Austria this critical positivism was known as empiriocriticism. Mach and Avenarius both held that facts (which for them, as for the other positivists, constituted the only reality) were relatively stable sets or groups of sensations connected to and dependent on each other. Sensations are the simple elements which figure in the constitution both of physical bodies and of perceptions or consciousness or the self. These elements are neutral, neither physical nor psychical, and every substantial difference between the physical and the psychical disappears. From this point of view, a "thing" is a set of sensations and the thought of the thing is the same set considered as "perceived" or "represented." For Avenarius, however, the process of interiorization, which he called introjection, and by which the thing is considered as a modification of the subject or as a part of consciousness, is a falsification of "pure" (that is, authentic or genuine) experience. For Avenarius and Mach, science, and knowledge in general, is only an instrument which the human organism uses to confront the infinite mass of sensations and to act in the light of those sensations in such a way as to conserve itself. The function of science is, therefore, economic, not contemplative or theoretical. It conforms to the principle of least action, and its end is the progressive adaptation of the organism to the environment.

Theories concerning concepts, scientific laws, and causality very different from those of classical positivism are

the chief results of empiriocriticism. According to Mach a concept is the result of a selective abstraction that groups a large number of facts and considers those elements of these facts that are biologically important—that is, those adapted to excite the appropriate reaction in the organism. Since the variety of the biologically important reactions is much smaller than the variety of facts, the first task is to classify and simplify the facts by means of concepts, each of which constitutes the project of an appropriate reaction. And since the interests with which men confront facts are different, there are different concepts which refer to the same order of facts. The laborer, the doctor, the judge, the engineer, and the scientist all have their own concepts, and they define them in those restricted ways which are appropriate for stimulating the reaction or set of reactions in which each is interested.

The concept of law, which classical positivism conceived of as a constant relationship among facts (a relationship which in turn was considered as a fact) underwent a radical transformation in critical positivism. The Englishman Karl Pearson, in *The Grammar of Science* (1892), gave a kind of *summa* of the fundamental principles of the science of the time. Although Pearson's work utilized Machian concepts, it supplied Mach himself with many inspirations. Pearson affirmed that scientific law is a description, not a prescription: It "never explains the routine of our perception, the sense-impressions we project into an 'outside world.'" Instead of description, Mach preferred to speak of a restriction that the law prescribes on our expectation of phenomena. In any case, he added, "Whether we consider it a restriction of action, an invariable guide to what happens in nature, or an indication for our representations and our thought which bring events to completion in advance, a law is always a limitation of possibilities" (*Erkenntnis und Irrtum*, Leipzig, 1905, Ch. 23).

Mach and Pearson sought to free the notion of causality from the notion of force, which they regarded as an anthropomorphic interpolation. Mach held that the mathematical notion of function should be substituted for that of cause. When science succeeds in gathering various elements into one equation, each element becomes a function of the others. The dependence among the elements becomes reciprocal and simultaneous, and the relation between cause and effect becomes reversible (*Die Mechanik in ihrer Entwicklung*, 4th ed., Leipzig, 1901, p. 513). From this point of view, time, with its irreversible order, is real at the level of sensations and as a sensation. The time of science is, on the other hand, an economic notion which serves for the ordering and prediction of facts.

Along the same lines, a disciple of Mach, Joseph Petzoldt, proposed to substitute for the principle of causality the "law of univocal determination," which would also be applicable to cases of reciprocal action. According to this law, one can find for every phenomenon means which permit determination of the phenomenon in a way that excludes the concurrent possibility of different determinations. According to Petzoldt this law permits the choosing, from among the infinite conditions that either determine a phenomenon or are interposed between it and its cause, of those conditions which effectively contribute to the determination of the phenomenon itself.