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(*b*. Gray, France, 28 August 1801; *d*. Paris, France, 31 March 1877)

applied mathematics, philosophy of science.

Of Franche-Comté peasant stock, Cournot's family had belonged for two generations to the *petite bourgeoisie* of Gray. In his *Souvenirs* he says very little about his parents but a great deal about his paternal uncle, a notary to whom he apparently owed his early education. Cournot was deeply impressed by the conflict that divided the society in which he lived into the adherents of the *ancien régime* and the supporters of new ideas, especially in the realm of religion. One of his uncles was a conformist priest, the other a faithful disciple of the Jesuits, having been educated by them.

Between 1809 and 1816 Cournot received his secondary education at the *collège* of Gray and showed a precocious interest in politics by attending the meetings of a small royalist club. He spent the next four years idling away his time, working "en amateur" in a lawyer's office. Influenced by reading Laplace's *Système du monde* and the Leibniz-Clarke correspondence, he became interested in mathematics and decided to enroll at the École Normale Supérieure in Paris. In preparation, he attended a course in special mathematics at the Collège Royal in Besançon (1820–1821) and was admitted to the École Normale after competitive examinations in August 1821. However, on 6 September 1822 the abbé Frayssinous, newly appointed grand master of the University of France, closed the École Normale. Cournot found himself without a school and with only a modest allowance for twenty months. He remained in Paris, using this free time—which he called the happiest of his life—to prepare at the Sorbonne for the *licence* in mathematics (1822–1823). His teachers at the Sorbonne were Lacroix, a disciple of Condorcet, and Hachette, a former colleague of Monge. A fellow student and friend was Dirichlet.

In October 1823, Cournot was hired by Marshal Gouvion-Saint-Cyr as tutor for his small son. Soon Cournot became his secretary and collaborator in the editing and publishing of his *Mémoires* Thus, for seven years, until the death of the marshal, Cournot had the opportunity to meet the many important persons around the marshal and to reflect on matters of history and politics. Nevertheless, Cournot was still interested in mathematics. He published eight papers in the baron de Férussac's *Bulletin des sciences*, and in 1829 he defended his thesis for the doctorate in science, "Le mouvement d'un corps rigide soutenu par un plan fixe." The papers attracted the attention of Poisson, who at that time headed the teaching of mathematics in France. When, in the summer of 1833, Cournot left the service of the Gouvion-Saint-Cyr family, Poisson immediately secured him a temporary position with the Academy of Paris. In October 1834 the Faculty of Sciences in Lyons created a chair of analysis, and Poisson saw to it that Cournot was appointed to this post. In between, Cournot translated and adapted John Herschel's *Treatise on Astronomy* and Kater and Lardner's *A Treatise on Mechanics*, both published, with success, in 1834.

From then on, Cournot was a high official of the French university system. He taught in Lyons for a year. In October 1835 he accepted the post of rector at Grenoble, with a professorship in mathematics at the Faculty of Sciences. Subsequently he was appointed acting inspector general of public education. In September 1838, Cournot married and left Grenoble to become inspector general. In 1839 he was appointed chairman of the Jury d'Agrégation in mathematics, an office he held until 1853. He left the post of inspector general to become rector at Dijon in 1854, after the Fortoul reform, and served there until his retirement in 1862.

In the course of his long career as administrator, Cournot, who was extremely scrupulous in fulfilling his duties, was able to exert a strong influence on the teaching of mathematics in the secondary schools and published a work on the institution of public instruction in France (1864). At the same time he pursued a career as scientist and philosopher. While rector at Grenoble, he published *Recherches sur les prinipes mathématiques de la théorie des richesses* (1838). Between 1841 and 1875 he published all his mathematical and philosophical works.

Unassuming and shy, Cournot was considered an exemplary civil servant by his contemporaries. His religious opinions seem to have been very conservative. In politics he was an enthusiastic royalist in 1815, only to be disappointed by the restoration of the monarchy. In the presidential elections following the 1848 Revolution, he voted for Louis Eugène Cavaignac, a moderate republican. In 1851, sharply disapproving the organization of public instruction as directed by Louis Napoleon, he decided to become a candidate in the legislative elections in Haute-Saône; this election, however, was prevented by the coup d'état of 2 December.

Cournot's background and his education made him a member of the provincial *petite bourgeoisie* of the *ancien régime*. But as a civil servant of the July monarchy and the Second Empire, he became integrated into the new bourgeoisie of the nineteenth century. Of certainly mediocre talents as far as pure mathematics was concerned, he left behind work on the philosophy of science, remarkably forceful and original for its period, that foreshadowed the application of mathematics to the sciences of mankind. Nobody could express better and more humorously Cournot's importance than he himself when he reported Poisson's appreciation of his first works: "He [Poisson] discovered in them a philosophical depth—and, I must honestly say, he was not altogether wrong. Furthermore, from them he predicted that I would go far in the field of pure mathematical speculation but (as I have always thought and have never hesitated to say) in this he was wrong" (*Souvenirs*, p. 154)

Cournot's mathematical work amounts to very little: some papers on mechanics without much originality, the draft of his course on analysis, and an essay on the relationship between algebra and geometry. Thus, it is mainly the precise idea of a possible application of mathematics to as yet unexplored fields that constitutes his claim to fame. With the publication in 1838 of his *Recherches sur les principes mathématiques de la théorie des rishesses* he was a third of a century ahead of Walras and Jevons and must be considered the true founder of mathematical economics. By reducing the problem of price formation in a given market to a question of analysis, he was the first to formulate the data of the diagram of monopolistic competition, thus defining a type of solution that has remained famous as "Cournot's point." Since then, his arguments have of course been criticized and amended within a new perspective. Undoubtedly, he remains the first of the important pioneers in this field.

Cournot's work on the "theory of chance occurrences" contains no mathematical innovation. Nevertheless, it is important in the history of the calculus of probability, since it examines in an original way the interpretation and foundations of this calculus and its applications. According to Cournot, occurrences in our world are always determined by a cause. But in the universe there are independent causal chains. If at a given point in time and space, two of these chains have a common link, this coincidence constitutes the fortuitous character of the event thus engendered. Consequently, there would be an objective chance occurrence that would nevertheless have a cause. This seeming paradox would be no reflection of our ignorance.

This objective chance occurrence is assigned a certain value in a case where it is possible to enumerate—for a given event—all the possible combinations of circumstances and all those in which the event occurs. This value is to be interpreted as a degree of "physical possibility." However, one must distinguish between a physical possibility that differs from 0 (or 1)only by an infinitely small amount and a strict logical impossibility (or necessity).

On the other hand, Cournot also insisted on the necessary distinction between this physical possibility, or "objective probability," and the "subjective probability" that depends on our ignorance and rests on the consideration of events that are deemed equiprobable[1] since there is not sufficient cause to decide otherwise. Blaise Pascal, Fermat, Huygens, and Leibniz would have seen only this aspect of probability. Jakob I Bernoulli, despite his ambiguous vocabulary, would have been the first to deal with objective probabilities that Cournot was easily able to estimate on the basis of frequencies within a sufficiently large number of series of events.

To these two ideas of probability Cournot added a third that he defined as "philosophical probability." This is the degree of rational, not measurable, belief that we accord a given scientific hypothesis. It "depends mainly upon the idea that we have of the simplicity of the laws of nature, of order, and of the rational succession of phenomena" (*Exposition de la théorie des chances*, p. 440; see also *Essai*, I, 98–99). Of course, Cournot neither solved nor even satisfactorily stated the problem of the logical foundation of the calculus of probability. But he had the distinction of having been the first to dissociate—in a radical way—various ideas that still were obscure, thus opening the way for deeper and more systematic research by more exact mathematicians. He also was able to show clearly the importance of the applications of the calculus of probability to the scientific description and explanation of human acts. He himself—following Condorcet and Poisson—attempted to interpret legal statistics (*Journal de Liouville*, **4** [1838], 257–334; see also *Exposition de la théorie des chances*, chs. 15, 16). But he also warned against "premature and abusive applications" that might discredit this ambitious project.

More than for his mathematical originality, Cournot is known for his views on scientific knowledge. He defined science as logically organized knowledge, comprising both a classification of the objects with which it deals and an ordered concatenation of the propositions it sets forth. It claims neither the eternal nor the absolute: "There can be nothing more inconsistent than the degree of generality of the data with which the sciences deal—data susceptible to the degree of order and the classification that constitute scientific perfection" (*Essai*, II, 189). Therefore, the fundamental characteristic of the scientific object must be defined differently. "What strikes us first of all, what we understand best, is the *form*," Cournot wrote at the beginning of the *Traite de l'enchaînement des idées*, adding, "Scientifically we shall always know[2] only the form and the order." Thus, it was from this perspective that he interpreted scientific explanation and stressed the privilege of mathematics—the science of form par excellence. Even though establishing himself as forerunner of a completely modern structural concept of the scientific object, Cournot did not go so far as to propose a reduction of the process of knowledge to the application of logical rules. On the contrary, he insisted upon the domination of strictly formal and demonstrative logic by "another logic, much more fruitful, a logic which separates appearance from reality, a logic which connects specific observations and infers general laws from them, a logic which ranks truth and fact" (*Traité*, P. 6).

This discerning and inventive power orients and governs the individual steps of the strictly logical proof; it postulates an order in nature and its realization in the simplest ways[3] This suggests the opposition Leibniz saw in the laws of logical necessity and the architectonic principles that make their application intelligible (see, e.g., Leibniz' "Specimen dynamicum," in his *Mathematische Schriften*, Gerhardt, ed., VI, 234–246) Cournot also declared himself, on several occasions, a great admirer of Leibniz. But to him the reason that governs the discovery of natural laws was not due to divine wisdom—he was always careful to separate religious beliefs (to which, incidentally, he adhered) from philosophical rationality. Reason, within scientific knowledge, denoted the ineluctable but always hazardous contribution of philosophical speculation. "Everywhere," he assures us, "we must state this twofold fact, that the intervention of the philosophical idea is necessary as a guideline and to give science its dogmatic and regular form; it also must insure that the progress of the positive sciences is not hindered by the indecision of philosophical question" (*Essai*, II, 252). Thus philosophy, as research on the most "probable" hypotheses regarding the assumption of a maximum of order and a minimum of complexity, becomes an integral part of scientific practice. But if philosophical reason guides the organization of hypotheses, it is the role of logic, obviously, to exhibit consequences and of experience to provide the only evidence that can be decisive in their favor.[4]

From this analysis one must conclude that science cannot be defined as a pure and simple determination of causes. For Cournot the word "cause" meant the generative antecedent of a phenomenon. He wanted science to add to the designation of causes the indication of reasons, i.e., the general traits of the type of order within which the causes act. And since the indication of reasons stems from philosophical speculation, it can only be probable—within a probability that itself is philosophical—that knowledge will advance to the extent that hypotheses are refined and corrected on the basis of experience.

In this sense, Cournot's epistemology is a probabilism. And it is probabilism in another sense, too—since it insists upon the indissoluble connection between the "historic data" and the "theoretical data" in the sciences. Fortuitous facts, in the sense defined above, appear in our experience—by its very nature—and not through our ignorance of causes. These facts appear as knots of contingency within the tissue of theoretical explication and, according to Cournot, cannot be entirely removed from it.

The connection between science and history is defined more precisely by the classification of the sciences proposed in chapter 22 of the *Essai*. According to Cournot, the system of the sciences must show an order that his predecessors had vainly tried to reduce to one dimension. In order to describe this system, we need a double-entry table (Figure 1) that vertically approximates Comte's system of division: mathématical sciences, physical and cosmological sciences, biological and natural sciences, noological and symbolic sciences, political and historical sciences. Horizontally there are three series: theoretical, cosmological, and technical. The technical series gives a special place and autonomous status to certain applied disciplines the importance and development of which "depend upon various peculiarities of the state of civilized nations and are not in proportion to the importance and philosophical standing of the speculative sciences to which they should be linked" (*Essai*, II, 266)

The distinction between the theoretical and the cosmological series corresponds to the separation of a historic and contingent element. This element will always be present in the sciences, even in the theoretical sciences (with the exception, perhaps, of mathematics), and will become more and more dominant as one passes from the physical sciences to the natural sciences (see *Traité*, p. 251). But if the very nature of the process of scientific knowledge demands that the philosophical element cannot be "anatomically" seperated, it allows for the establishment of sciences in which the historic element controls the contents and the method of knowing.

Another kind of separation appears in the system of the sciences that Cournot set forth and developed in his works following the *Essai*. This separation is the radical distinction between a realm of physical nature and a realm of life.

For Cournot, the scientific explanation of the phenomena of life requires a specific principle that, in the organism, must control the laws of physics and chemistry. As for man's role among the living beings, it seems that Cournot linked it with the development of community life, for "the superiority of man's instincts and the faculties directly derived from it… would not suffice to constitute a distinct realm within Nature, a realm in contrast with the other realms" (*Traité*, p. 365). On the other hand, he adds, "When I see a city of a million inhabitants… I understand very well that I am completely separated from the state of Nature…" (*ibid*., p. 366).

This separation from the state of nature is accomplished by man in the course of a development that causes him to cultivate successively the great organizational forms of civilized life: religion, art, history, philosophy, and science. Cournot was careful not to interpret such a development as a straight and continuous march, yet he did not fail to stress that only scientific knowledge could be the sign of great achievement and alone was truly capable of cumulative and indefinitely pursued progress.

NOTES

1. Cournot's definition of an objective probability as the quotient of the number of favorable cases divided by the number of possible cases also entails a hypothesis of equiprobability of these various cases (*Essai*, ch. 2). Cournot does not seem to have noticed this difficulty, which later concerned Keynes and F. P. Ramsey.

2. According to Cournot, order is a fundamental category of scientific thought that can be deduced neither from time nor from space, which it logically precedes. Moreover, it cannot be reduced to the notion of linear succession. Without proceeding to a formal analysis, Cournot very often showed that by "order" he meant any relationship that can be expressed by a multiple-entry table.

3. But Cournot rebelled against the reduction of the principle of order to a maxim postulating the stability of the laws of nature (*Essai*, I, 90).

4. Cournot was always very careful to distinguish between philosophy and science. The following text shows a very rare lucidity, considering when it was written:

In a century when the sciences have gained so much popularity through their applications, it would be a vain effort to try to pass off philosophy as science or as a science. The public, comparing progress and results, will not be fooled for long. And since philosophy is not—as some would have us believe—a science, one could be led to believe that philosophy is nothing at all, a conclusion fatal to true scientific progress and to the dignity of the human spirit [*Considerations*, II, 222].

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