temporary representatives of any given group. If the great apes, for example, had developed the body-weight characteristics of baboons, their predicted range of k would be from .40 to 1.00. Second, and perhaps more important, within the range of values of log P for each of the groups in Fig. 2, Eq. 4 approximates the slopes of the regression lines that could be fitted to the data. Thus, a single rational function has been written, which, when applied to these primates, replaced four empirical equations otherwise necessary to describe the data. It is of some interest that Eq. 4 was written before human data were analyzed, and, as can be seen in Fig. 2, it predicted with some success the slope of the regression of log P on k for man.

Assumption iii, which is fundamental to this analysis, is, of course, a simplification. However, because of the success of Eq. 4 in accounting for our data, it seems reasonable to examine the possibility that this assumption is approximately correct. To do this, it would be necessary to determine precise relationships between number of neurons and brain weight, neuron weight and brain weight, neuron weight and body weight, and similar relationships between weights of other cellular constituents of the brain and the total brain and body weight. But even without such information to lend precision to the present analysis, the suggestion that a large portion of the primate brain weight is independent of the body weight may be important. It indicates, for example, that a specific anatomical correlate for intelligence may be found by pursuing quantitative anatomical studies of the relative development of parts of the brain in monkey, ape, and man as a function of the body weight. Rensch's recent work (*9*) appears especially important in this context.

A more difficult aspect of the third assumption involves the definition and measurement of intelligence in animals. This is largely an unsolved problem, but the present approach suggests that in seeking a solution it would be appropriate to compare species in terms of their values of E_c. In the monkeys, for example, we would expect no differences between *Macaca mulatta* and *M. nemestrinus,* but these forms should be differentiable from the baboons. This analysis can, thus, be considered as contributing to an important problem in comparative psychology, namely, the development of criterions for selecting species for comparisons.

In summary, the general relationship between brain weight and body weight enables us to estimate the expected brain weight for any given body weight. Deviations from the expected brain weight in the primates can be accounted for by assuming a special evolution of the brain in the direction of the development of additional cerebral tissue, the weight of which is independent of the body weight. This approach results in a solution of problems arising from inconsistencies in the "index of cephalization" of primates and suggests directions for further research on the evolution of the brain and intelligence.

References and Notes

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Enrico Fermi

IF the earmark of genius is ability to reach the summits of creative thought by personal, unsupported effort, Enrico Fermi ranks extremely high among the scientists of our time. He was born in Rome on 26 September 1901. In his childhood he began to manifest an extraordinary interest in mathematics and physics, although there was nothing in the family environment—his father was a railway official—to induce an overpowering desire for these forms of abstract knowledge. During his high-school years Fermi absorbed and thoroughly mastered the contents of an odd assortment of books on higher mathematics, mechanics, and classical theoretical physics, including the theory of relativity.

In 1918 Fermi entered the University of Pisa, where he had little to learn from his teachers, since in most fields his knowledge already equaled or excelled theirs. Thus, he could devote himself fully to the study of the quantum theory, which had developed during and immediately after World War I, chiefly through the work of Planck, Bohr, and Sommerfeld, and which was virtually unknown to Italian physicists. At 21 he received the Ph.D. degree by, strangely enough, presenting an experimental dissertation on x-rays, even though he had already written several important theoretical papers ranging from classical mechanics to statistical mechanics and general relativity.

Fermi then visited the universities of Leiden and Göttingen and met several members of that brilliant galaxy of theoretical physicists of his own age—he was then in his early 20's—including, among others, Dirac, Heisenberg, and Pauli. These men had had the benefit of the teachings of great masters, such as Bohr, Born, and Sommerfeld; yet Fermi, self-taught, still unknown internationally, did not feel their inferior. In 1926, while teaching theoretical physics at the University of Florence, he published his celebrated paper on the statistical mechanics of particles obeying the Pauli exclusion principle (such as electrons), now collectively designated as *fermions*. This work immediately won him international fame, since Sommerfeld recognized its revolutionary significance for understanding the properties of conduction electrons in metals and many other phenomena.

Fermi's reputation in Germany spread to his own country, where few people had been aware of his exceptional originality as a theoretical physicist. One of these few was Orso Mario Corbino, chairman of the physics department of the University of Rome. Corbino secured for Fermi a chair of theoretical physics in Rome with the possibility of attracting collaborators to found a small school of modern physics. For the first time in more than a century, an Italian school of physics attracted foreign scientists, chiefly young theoreticians. Among the brilliant physicists who came to Rome for extended periods in the early 1930's in order to work with Fermi were Bethe, Bhabha, Bloch, London, Peierls, and Placzek.

In 1933 Fermi published another of his fundamental contributions to theoretical physics, and his first in the nuclear field: "The theory of beta-decay." By this time Fermi had won full recognition in his native country. Since 1928 he had been a member of the Royal Italian Academy, a body created by Mussolini to supervise the cultural life of the nation. Fermi brought into the academy the beneficial influence of his unwavering integrity and high intellectual standards. He was influential in determining new appointments of physics professors in Italian universities exclusively on the basis of scientific merit, regardless of personal influence. He so raised the standards in physics that even now, 17 years after his departure from Italy, a small but very active group is well known internationally for continuing the tradition of modern, high-quality research that he established almost singlehanded.

Fermi's theoretical studies on the structure of the nucleus and the discovery, by Curie and Joliot, of the artificial radioactivity induced by alpha-particle bombardment led him to try to produce similar effects by neutron irradiation. The striking success of this work, Fermi's first major venture in the experimental field, is well known. More than 60 new radioactive nuclei were discovered within a few months in the spring of 1934. In the fall of the same year, the not less startling discovery of the peculiar properties of slow neutrons followed. The results were presented at an international physics meeting in London, and Lord Rutherford himself expressed amazement at the fact that such great experimental achievements were the work, to use his own words, of "a theoretical physicist of the deepest dye." The life of the physicists in Rome during this period (when, as one of Fermi's former students, Emilio Segré, aptly put it, Rome became for a while "the capital of the nuclear world") is vividly portrayed in *Atoms in the Family* by Laura Fermi, whom Fermi had married in 1928. It soon became apparent that these discoveries opened the possibility, at that time thought very remote, of a large-scale release of nuclear energy.

In 1938 Fermi was awarded the Nobel prize for these experimental discoveries. There is no doubt that, had he never done any experimental work, his theoretical achievements would have made him well worthy of that distinction. At the same time, the increasing Fascist control on national life, and especially the racial persecution following the Axis alliance, made him look longingly to the United States, where universities enjoyed freedom from political pressure. After visiting Stockholm to receive the Nobel prize, he sailed directly to the United States with his wife and two children, having accepted a professorship at Columbia University.

As soon as the discovery of nuclear fission by Hahn and Strassmann made the practical utilization of nuclear energy seem much less remote than before, Fermi undertook preliminary experiments on neutron multiplication and moderation, aiming at the goal of a self-sustaining chain reaction. This work was soon covered by the blanket of military secrecy, and most people did not realize, until the publication of the Smyth Report at the end of the World War II, the historic event that had taken place in Chicago on 2 December 1942. There, after building a uranium-graphite pile, Fermi had achieved the first large-scale release of nuclear energy and opened its immense military, economic, social, and political consequences. Fermi also played an important part in subsequent developments at Los Alamos. After the war, he resumed peacetime research in Chicago, first on neutron optics and later, with the construction of the large synchrocyclotron, in the still mysterious and fascinating domain of the high-energy interactions between nucleons and the related new elementary particles.

It is not possible to give here even a remote idea of the vastness and depth of Fermi's work in almost all branches of physics, from classical mechanics to relativity and statistical mechanics, from spectroscopy to quantum electrodynamics, and from nuclear physics to cosmic rays, to mention but some of the fields of physics on which he left the indelible imprint of his genius. If, in theoretical physics, he was second to none, as a combination of a theoretician and an experimenter he was unique. For this reason, among others, he enjoyed unequaled authority and prestige. Other qualities that won him universal admiration were an extraordinary degree of personal disinterestedness and his excellence as a teacher. For Fermi, the advancement of science and the loyalty to institutions devoted to this purpose came first; personal advantages mattered nothing. Hence, his opinions, not only on purely scientific matters, but also on questions more susceptible to distortion by human passions, always carried great weight.

Fermi was also an incomparable teacher, from the time, in his college years, that he introduced me and a few other fellow-students to the first mysteries of theoretical physics. He was gifted with great clarity and orderliness of exposition; many times a question asked by one of his students or colleagues was answered by a masterful, exhaustive, improvised lecture on the subject which, if taken down word for word, could have been sent almost unchanged to the editor of a scientific journal. Physicists familiar with his work well know the outstanding clarity and thoroughness of all his publications; for example, the treatment given in his historical papers on Fermi statistics and the theory of beta-decay is so perfect that hardly a word need be changed or added even today, more than a score of years after those articles were written. Also well known for easily readable treatments of difficult subjects are his 1932 article on the quantum theory of radiation and his book, *Elementary Particles,* which records the contents of the 1950 Silliman lectures.

Fermi was probably the most sought-after lecturer in physics of the last two decades. Universities, academies, and other scientific institutions all over the world vied in securing his participation in lectures, meetings, and symposiums, certain that his presence would stimulate creative discussion and often lead to important advances. During the summer of 1954 Fermi lectured, for the last time, at the schools of advanced physics at Les Houches in France and Varenna in Italy. His mind was as brilliant as ever, but his body was beginning to suffer from the attacks of a fatal disease. Most of his colleagues hardly suspected the gravity of his illness, and they were greatly shocked, when the man, who, more than any other single individual, fathered the advent of the atomic age, passed away in Chicago on 28 November 1954.

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Beryllium-7 Produced by Cosmic Rays

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In his classic paper of 1946, W. F. Libby (*1*) predicted the existence of cosmic-ray-induced radioactivities in the atmosphere, in particular C^{14}, with a half-life of 5600 yr. and tritium, with a half-life of 12.4 yr. Both nuclides have now been discovered and used to study a wide variety of processes having time-scales comparable to their respective half-lives (*2*). Carbon-14 is made by low-energy neutron capture in nitrogen, whereas tritium results chiefly from high-energy interactions, or "stars."

Two other nuclides may be expected to result from these high-energy interactions in nitrogen and oxygen. These are Be^7, with a half-life of 53 days, and Be^{10}, with a half-life of 2.5×10^6 yr. Because of their well-spaced half-lives these species should be of geochemical interest. This paper (*3*) reports the discovery of cosmic-ray produced Be^7.

Our picture of the history of this nuclide is as follows. The peak of the star production occurs about 15 km above the surface (*4*). Beryllium formed at this height will form BeO, or just possibly $Be(OH)_2$. The nonvolatile molecule will diffuse in the atmosphere until it encounters a dust particle, to which it will adhere. Its further history is that of the upper atmosphere dust.

It appeared probable that the great majority of upper atmosphere dust particles ultimately form cloud nuclei, which are carried down in rain, or are otherwise washed out by rain. Rain water then seemed a likely location for Be^7. A series of rain-water samples taken at Chicago and at Lafayette, Indiana, were analyzed for this nuclide.

In each case a sample of rain water of 5 to 50 gal was collected from a roof (it therefore included some "between-rains" dust), 1 to 2 ml of Be^{++} carrier per gallon (5 mg BeO/ml) was added, with sufficient nitric acid to bring the *p*H to about 3. After thorough agitation, the solution was brought to *p*H 9 with ammonia, precipitating $Be(OH)_2$ along with substantial quantities of $Fe(OH)_3$ and other species present in rain water in this industrial area or originating in the cans used for collection in some cases. This flocculent precipitate served as a general carrier. After the sample had been allowed to stand for 30 min or more, it was filtered, and the clear filtrate was discarded.

An early experiment showed that all the activity remained in the precipitate at this point. The precipitate was ashed and fused with $KHSO_4$. After the supernate was leached and centrifuged, it was scavenged with CuS and then was made strongly basic to precipitate $Fe(OH)_3$ and other group-III hydroxides. The supernate was acidified and then made basic with NH_4OH, yielding a precipitate containing the $Be(OH)_2$. This was then put through an acetate-chloroform cycle following McMillan (*5*) and finally was precipitated as $Be(OH)_2$ and ashed to BeO.

The yields for this procedure were erratic but improved with experience; they range from 20 to 80 percent in the samples reported. Radiochemical purity