HERMANN LUDWIG FERDINAND VON HELMHOLTZ, who died at Charlottenburg on the 8th of September, 1894, was born at Potsdam on the 31st of August, 1821. His father, Ferdinand Helmoltz, was a schoolmaster, teaching literature specially, at the Potsdam Gymnasium; his mother (Caroline) was the daughter of a Hanoverian officer, Penne, a descendant of William Penn. He left the Potsdam school in 1838, and began the study of medicine at the Friedrich-Wilhelm Institute (Pegriinière) in Berlin. Thence he issued as doctor medicinae in 1842, and took up the career of a military surgeon whereby to earn a livelihood.

But his genius having become apparent to Johannes Müller and Alexander von Humboldt, they successfully exerted their influence to secure his exemption from military duties in 1848, and obtained for him the lectureship on Anatomy at the Berlin Academy of Arts. A year later he was called to the Chair of Physiology at Königsberg, and began his memorable studies in physiological optics. In 1855 he was made Professor of Anatomy and Physiology in the University of Bonn, and in 1858 Professor of Physiology at Heidelberg. While at Bonn (strange occupation for a professor of anatomy) he performed one of his most noteworthy achievements, viz., the integration and discussion of the hydrodynamical equations expressive of vortex motion, and so laid the foundation of the modern mathematical treatment of vortices. From Heidelberg issued his great experiments and observations on acoustics and the mechanism of hearing, constituting a series of memoirs which were afterwards embodied in his "Tonempfindungen."

It was now evident that whatever else he might be, he was a physicist of the first order, and so, in 1871, he was summoned to Berlin and there installed in the Chair of Physics. He continued to hold that office until 1887, when he accepted the Presidency of the Physikalisch-Technische Reichsanstalt, then newly established by the German Government, at Charlottenburg, near Berlin.

He had been raised to nobility by the Emperor Wilhelm I in 1882, and in 1891 Wilhelm II conferred upon him the title of "Excellenz" as a mark of signal favour and personal friendship.

Helmholtz was twice married, first to Olga von Velten, daughter of a military surgeon; a son of this marriage is now
an engineer at Munich. His second marriage was with Anna von Mohl, daughter of Professor von Mohl, of Heidelberg. Their eldest son, Robert, was a physicist, and showed signs of possessing much of his father's genius; but he died in the prime of life, just as his abilities were becoming known to the world. A younger son is still studying. There was only one daughter, who is married to a son of Werner von Siemens.

The following are his books:—

1. "Wissenschaftliche Abhandlungen," published by Johann Ambrose Barth, of which the first two volumes are out and the third is in the press.

2. "Vorträge und Reden" (Vieweg & Sohn), two volumes, which have been translated into English under the editorship of Dr. Atkinson.

3. "Handbuch der physiologische Optik" (Georg Maas), a book of which a second edition has been begun.

4. "Lehre von den Tonempfindungen" (Vieweg), which has passed through two English editions, with enlargements by Mr. A. J. Ellis.

5. An edition of his lectures (Georg Maas), which unfortunately was only commenced by himself, and will now be finished by some former pupils.

In addition to these, it is well known that Taylor's scientific memoirs contain a translation of his 1847 treatise, "Ueber die Erhaltung der Kraft" (which is not to be confused with the more popular exposition of much later date, which appears in the volumes of "Popular Scientific Lectures"); that the Physical Society of London has translated and issued some of his memoirs on electrolytic and chemical subjects—on which he delivered the "Faraday Lecture" of 1881; and that Professor Tait translated his papers on vortex motion, of which an abridgment was printed in the *Philosophical Magazine* for 1867.

The work of Helmholtz lay in the departments of Mathematics, Physics, and Physiology, and his influence upon science owes much of its magnitude to the fact that he was able to apply the methods and the truths of one science to the elucidation of another. It was in the overlapping regions of science that his power was unique.

In Physiology a series of memoirs appeared between 1842 and 1856, the principal outcome of which was the determination of the velocity of nerve transmission, of the time of muscular contraction, and, most important, of the heat set free in muscular
action. He also introduced methods of investigation—some of them; previously devised by Pouillet—such as the graphical recording cylinder, the Fick pendulum, the myograph and other physical appliances, which now form the classical instruments of the physiological laboratory. He likewise tried to show that fermentation depended on something which could be filtered out by an endosmotic membrane, and through his microscope he saw some of the vibrios concerned; but the proof that fermentation could not go on without life was completed by Pasteur many years later.

The series of principal memoirs on Physiological and Physical Optics date from 1851 to 1878, and deal with a great number of subjects connected with vision, among which may be mentioned specially colour-blindness, the theory of accommodation of the eye, and optical illusion; with the very practical and early outcome—the ophthalmoscope, whereby it became possible, in 1851, for the first time to inspect the healthy human retina in action. Among other optical subjects were the visibility of ultra-violet light, the theoretical limit of microscopic vision, a discussion of theories of anomalous dispersion, the mechanism and importance of the movements of the human eye, and papers on stereoscopic vision and the principal means whereby relative distance is estimated.

In Physiological and Physical Acoustics the chief memoirs range from 1848 to 1869, and their main result is little less than a physical theory of Music, especially the explanation of the cause of dissonance and the amount of harmony in musical intervals, by means of beats. In them are given the well-known theory of combination tones, the resonance theory of musical sensation in the cochlea, and the doctrine concerning vowel sounds; all of which, though advocated with immense power and learning, have not escaped the ordeal of severe criticism. Nor can it be maintained that the theory of vowel sounds as promulgated by Helmholtz is finally complete and satisfactory. Probably the same is true of his theories of colour-blindness and of the mechanism of the perception of pitch. The doctrine of harmony seems fairly to hold its ground and to slowly make its way towards acceptance by musicians, although, since no theory of melody is so much as begun, it also will probably require supplementing and possibly modifying in the light of future knowledge.

But whether these difficult questions concerning the details of sense-perceptions and the modes of action of sense-organs are to be regarded as settled or not, there can be no question but
that the work of Helmholtz has stimulated research in these directions, and has not only increased definite knowledge of the subject, but has also furnished the means of obtaining more by working further on the same lines. His work in Acoustics has been popularised in England especially by Tyndall, whose lectures on the subject were mainly derived from Helmholtz sources.

Appropriately concurrent with the treatment of the great channels of sense-perception, Helmholtz discussed certain Psychological and Philosophical problems, such as the nature of human sense perception and the theory of cognition, the fundamental axioms of geometry, and other questions of experimental psychology—a subject in which he took a deep interest. But here a word of correction may be permitted. Because he attended a meeting of the Psychological Congress, held in London in 1892—a meeting presided over by the President of the Society for Psychological Research, many of the members of which took part in the proceedings—it has been conjectured and even publicly stated that Helmholtz was willing to lend his countenance to their investigations into facts not yet recognised by orthodox science. This, however, is a mistake, for there is high though posthumous authority for the assertion that “although always very interested in scientific experimental psychology, and working at it himself in connection with Fechner’s law (on the whole regarding with more approbation the methods of Professor Strumpf than those of Professor Wundt), yet to every sort of mystical psychology he was in the strongest opposition, and severely disapproved of the mania of our century for marvels.”

Under the head of Laws of Energy may be grouped a few memoirs, among which that on the development of heat during muscular contraction and the one on the conservation of energy are the chief. This last is indeed one of the most remarkable monuments of his genius, showing a profound grasp of the fundamental principles of physics, so long ago as 1847. Nothing is more astonishing than the way in which he therein takes up one branch of physics after another, and shows how an application of the universal principle suffices to disentangle new laws and relations among complex phenomena without the necessity for probing into and understanding their processes in detail. Another important though minor discovery coming under the same head was his proof that the solar heat might be, and probably was, caused by the energy of its own gravitational shrinkage or earthquake subsidence, and that it, like other stars of enormous size, might conceivably be getting hotter instead of cooler.
The memoirs on Hydrodynamics, which include some on the theory of stationary waves in viscous liquids, on discontinuous liquid motion, and other matters relating to the hydrodynamics of real as opposed to perfect fluids, were introduced in 1858 by the integration of the equations expressing the vortex motion of a liquid, and the establishment of many of the properties of vortex rings by most ingenious and clear-sighted reasoning and perception of the inner meaning of what would to many mathematicians have remained cold and irresponsible formulas.

Among the Chemical and Electrolytic papers the most important probably are those on the thermodynamics of chemical processes, wherein Helmholtz developed certain ideas analogous to those introduced in another form by Willard Gibbs, and by his doctrine of so-called "free energy" helped to lay the foundation of a future mathematical theory of chemistry. Of his electrolytic works, probably the most important are the experimental investigations into the behaviour of a gas-free cell, and the verification in actual fact of conclusions deduced from the laws of thermo-chemistry—conclusions which, on a superficial estimate of known facts, seemed to be, and by some were supposed really to be, at variance. The electrolytic views expounded in the Faraday lecture, though simple and helpful enough, were not really beyond those at which other disciples of Faraday had arrived about the same time, and did not therefore advance the boundaries of knowledge further than must inevitably be the result of a clear and authoritative exposition.

His application of the theory of electric boundary-layers to electric endosmose and electro-capillary phenomena generally, and his explanation of the electrification observed by Quincke, Edlund, and others, when streams of liquid flow along narrow tubes; his application of the second law of thermodynamics to complete Lord Kelvin's theory of the calculated electromotive force of a voltaic cell in terms of its rate of variation with temperature, are all matters of considerable interest.

It will be observed that in every one of the great branches into which his profound researches have been classified, each is characterized by some epoch-making discovery or invention or memoir of classical importance, forming a starting-point for further research—a basis or method for future discovery. But there is one group of memoirs, and that the most extensive, not yet touched upon,—those relating to Electrical Theory. Out of the influence and inspiration of Helmholtz' electrical teachings arose the brilliant work of Hertz, and that alone entitles them to more than respectful consideration and gratitude.
To what manner of man is it that these great discoveries and brilliant inspirations are vouchsafed? Most fortunately there is a beautiful self-drawn portrait, an autobiographical sketch, which will probably be as highly prized by posterity as anything that this great man achieved; for in it he glances back over his own past career and quietly asks, how came it that I did this and that? how comes it that this that I did is so amply recognised? wherefore is it that after all men call me great? And as answer he is shown going about his work thinking the thoughts that come to him, keeping his mind open and receptive, and his brain as clear and unembarrassed as this busy century would let him, happy in belonging to the studious German nation, which takes pride in a learned man and does not wish him to enter politics or to adopt any other career than the one for which heaven has fitted him, but leaves him to flourish, and to obtain such honour as it can give, in his own true sphere. A childlike simple man, to whom great thoughts come easily and do not overburden him. They come to him as he walks or while he is waking. “They steal into the line of thought without their importance being at first understood.” Sometimes “they occur suddenly without exertion like an inspiration,” but “they never come at the desk or to a tired brain.” “I have always so turned my problem about in all directions that I could see in my mind its turns and complications and run through them freely without writing them down. But to reach this stage was not usually possible without long preliminary work. Then after the fatigue of this work had passed away, an hour of perfect bodily repose and quiet comfort was necessary before the good ideas came.” Then he goes on to say that, as happened to Goethe and to Gauss, his good ideas often came in the morning on waking; and that to himself they also frequently came, as at Heidelberg, “when comfortably ascending wooded hills in sunny weather.” But, on the other hand, sometimes the delightful moments of fruitful thought would not come, and “he would gnaw for weeks or months at a refractory problem in his mind, until a sharp attack of headache released him from the strain and set him free for other work.”

It is interesting to realize how the achievements of genius appear to their originator, and upon this also Helmholtz lets some light. When expressing surprise at the honours heaped upon him and at the high estimate placed upon his work, he says:—

“I know how simply everything I have done has been brought about; how scientific methods worked out by my predecessors have naturally led to certain results, and how frequently a fortunate circumstance or a lucky accident has
helped me. But what I have seen growing from small beginnings, through months and years of tentative work, all that suddenly starts before you like Pallas fully equipped from the head of Jupiter; a feeling of surprise has therefore entered into your estimate but not into mine.”

His remarks on his early aptitudes and education are very instructive. He says:—

“In my first seven years I was a delicate boy, for long confined to my room and even to bed, but I had a strong inclination towards occupation and mental activity. My parents busied themselves a good deal with me; picture-books and games, especially with wooden blocks, filled up the rest of the time. The first laws of phenomena I got to know were in geometry. From the time of my childish playing with wooden blocks the relations of special proportion to each other were well known to me from actual perception. What sort of figures were produced when bodies of regular shape were laid against each other I knew well without much consideration. When I began the scientific study of geometry, all the facts which I had to learn were perfectly well known and familiar to me, much to the astonishment of my teachers.”

“One thing, however, was wanting in geometry, it dealt exclusively with abstract forms of space, and I delighted in complete reality; . . . . the first fragments of physics which I learnt in the gymnasium engrossed me much more closely than purely geometrical and algebraical studies had done. Here was a copious and multifarious region, with the mighty fulness of nature, to be brought under the dominion of a mentally apprehended law. And in fact that which first fascinated me was the intellectual mastery over nature, which at first confronts us as so unfamiliar, by the logical force of law.”

“I must confess that many a time when the class was reading Cicero or Virgil, both of which I found very tedious, I was calculating under the desk the path of rays in a telescope; and I discovered even at that time some optical theorems, not ordinarily met with in text-books, but which I afterwards found useful in the construction of the ophthalmoscope.”

Some other reminiscences about his mental aptitudes and disabilities are likewise full of interest and instruction. “Reading,” he says, “came pretty easily; but a defect of my mental organization showed itself almost as early, in that I had a bad memory for disconnected things.” He had a difficulty at first even in distinguishing between left and right; and “afterwards, when at school I began languages, I had greater difficulty than others in learning words of irregular grammatical form and peculiar idioms. History as then taught to us I could scarcely comprehend. To learn prose by heart was martyrdom.” On the other hand, poetry, so long as it was full of consecutive thought and good rhythm, he could learn readily enough; and, later on, he could repeat whole “books of the Odyssey, a considerable number of the odes of Horace, and large stores of German poetry.” His father was an enthusiast for poetry, particularly for the classic period of German literature, and trained the boys in composition on set themes alternately in prose and in verse; and so,
“even if most of us remained indifferent poets, we learned better in this way than in any other I know of, how to express what we had to say in the most varied manner.”

That he did not stand out specially in ordinary school studies was to be expected. “Mathematics was always regarded in the school as a branch of secondary rank. In Latin composition, on the contrary, which then decided the palm of victory, more than half my fellow-pupils were ahead of me.”

Proceeding to his student career, which began in medicine, because Physics was regarded as a subject in which a living could not be made, he acknowledges the inspiring influence of Johannes Müller (in whose laboratory he had worked along with du Bois-Raymond, Brücke, and Ludwig as co-students), and relates how he was led into cogitation and arguments on the deepest problems, such as those connected with the question of a “vital force.” In the course of this struggle, he perceived that many vitalists were practically regarding an animal as a perpetual-motion machine, out of which more work could be got than energy was put in, and so from it arose his essay “Über die Erhaltung der Kraft,” which he wrote for the benefit of physiologists; but, to his surprise, he found that the physicists themselves were unprepared for it, and some of them were inclined to quarrel with it as a “fantastical speculation,” analogous to those of Hegel against which they were accustomed to tilt.

He went on with investigations into the heat of muscular action, and into the chemical decompositions occurring in the animal organism considered from the energy point of view. It was on account of these researches that Johannes Müller was able to prevail on the Prussian Ministry of Instruction in early days to establish him in Berlin as successor to Brücke, and immediately afterwards to send him to the University of Königsberg.

“A University Professor,” he says, “undergoes a very valuable training in being compelled to lecture every year on the whole range of his science, in such a manner as to convince and satisfy the intelligent among his hearers—the leading men of the next generation.” This, doubtless, is true everywhere, but must be especially true in an educated country like Germany, where the youths come from school sufficiently instructed in the rudiments of knowledge, so that a foundation for future real study has already been laid before they reach the University.

“In preparing my course of lectures I hit directly on the possibility of the ophthalmoscope, and then on the plan of measuring the rate of propagation of excitation in the nerves.”
The ophthalmoscope, as rigged up with spectacle lenses and other ordinary means, "was at first difficult to work; and without an assured theoretical conviction that it must work I might perhaps not have persevered. But in about a week I had the great joy of being the first who saw clearly before him a living human retina." The retinal image is formed by the eye's own lens, and the invention consists in recognising this fact and in devising means for making the image visible.

Helmholtz ascribes much of his success to the circumstance that "possessing some geometrical capacity, and equipped with a knowledge of physics, he had found in physiology a virgin soil of great fertility, while on the other hand he was led by the consideration of vital processes to questions and points of view which are usually foreign to pure mathematicians and physicists." The "geometrical" method of regarding things—in other words, a clear mental grasp, without symbols, of the conditions of a problem—must be an essential to a real physicist as distinct from a mere mathematician; but there is no need to press the adjective geometrical to mean more than what might be still more generally expressed as vivid full-bodied mental representations.

His successes and the veneration of contemporaries (which must have been an extremely marked feature in his later life) were far from leading him into an over-estimate of himself or into self-admiration.

"I have often enough seen how injurious an exaggerated sense of self-importance may be for a scholar, and hence I have always taken good care not to fall a prey to this enemy. But it is only needful to keep the eyes open for what others can do, and what one cannot do oneself, to find that there is no great danger; and as regards my own work, I do not think I have ever corrected the last proof of a memoir without finding, in the course of twenty-four hours, a few points which I could have done better or more carefully."

"The writing out of scientific investigations is usually a troublesome affair; at any rate it has been so to me. Many parts of my memoirs I have rewritten five or six times, and have changed the order about until I was fairly satisfied. But the author has a great advantage in such a careful wording of his work. It compels him to make the severest criticism of each sentence and each conclusion. . . . I have never considered an investigation finished until it was formulated in writing completely and without any logical deficiencies."

One of his pupils, Dr. Kronecker, says that his estimate of the value of popular exposition was a high one, and he never thought it beneath him to lecture and write in a popular style. He was able to explain difficult problems in mathematics, in physical science, or in philosophy, in a clear and beautiful manner. He never sank to the level of his audiences, he drew them up towards himself.

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For music and natural scenery he was an enthusiast, and pilgrimages to Baireuth and thence to the Engadine and the Tyrol were frequent.

At the age of seventy-three he was still in possession of much power of work, as well as of ripe judgment and inspiring influence over younger men, but the supposed exigencies of a formidable journey to Chicago have sufficed to deprive the world of the later years of this magnificent life. It will serve no purpose now to inquire why such an unsuitable and useless journey was ever permitted or enforced. The report that such a journey was to be undertaken was received in England with regret, only too well justified by the fatal consequences. The services of such a man are not to be limited by national boundaries nor acknowledged with constricted gratitude; he belongs to the world and to nothing less. The possession of a great genius is a great responsibility, not every nation is worthy of it. Fortunate were the German people in receiving into their midst so indomitable and persevering a worker, so single-hearted and estimable a man; and they have proved themselves well worthy of the trust. Throughout his later life they held him in highest honour, and they provided him with material resources such as no other nation at the same epoch was likely to bestow. Honourable his life has been, both to man and to nation; and the world, though blind to many things of high and noble import, has in this case no cause to regret that the man came before his time, or that he spoke to a faithless and perverse generation.

Von Helmholtz was elected as an Honorary Member of the Institution on the 9th of January, 1894.

On receiving the intimation of his nomination for election, he despatched the following telegram:

"Charlottenburg, December 15th, 1893, 6-5 P.M.

Secretary of Institution of Civil Engineers,
JAMES FORREST, ESQ.,
25, Great George Street, Westminster, London.

Greatly honoured I gratefully accept nomination for election as Honorary Member of your great Institution.

HELMHOLTZ."

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