some simple arithmetic will provide a rough estimate of the possible limits of many-strandedness assuming this to exist. The higher limit for the 'size of a gene' is given as 300 A. and there would therefore be room in a quarter chromosome of *Todea* for some 75 threads of this width. The lower limit of size is given as 'ten atomic distances cubed' which, for a protein molecule, might perhaps be put as of the order of 50 A. cubed. There is room in a quarter chromosome of *Todea* for nearly three thousand threads of diameter 50 A. The real unit of chromosome structure is likely to lie in between these two extremes and it is probable that allowance must also be made for some empty spaces between the strands. Nevertheless the figures, rough as they are, indicate at least the possibility that in a whole chromosome, not one but between 300 and 12,000 duplicate versions of the genetical material may be present.

This is not quite the same as the unique phenomenon visualized by Prof. Schroedinger, though it is no doubt sufficiently close to it still to come under the general heading of 'order from order' rather than 'order from disorder'. The importance attributed to atomic arrangement in the 'aperiodic solid' of the unit fibre is almost certainly correct, and this property is shared by many other protoplasmic structures besides the chromosomes, notably by enzymes. If the view of chromosome structure put forward above be correct, however, a chromosome may be found to owe some of its peculiar powers not to the aperiodic fibre as such but to the fact that bundles of these are co-ordinated together in a manner recalling, though not necessarily exactly resembling, the periodic crystals. The 'whole chromosome fibre' may in fact have to be visualized as an aperiodic solid in its longitudinal dimension but as periodic in its transverse dimension.

The recognition of an element of periodic structure in one dimension of the genetical material would perhaps be a minor emendation in the general philosophic view of a chromosome. The issues raised are, however, of immediate importance in cytology, and I trust that Prof. Schroedinger will forgive me if I have used his very interesting little book as an occasion for directing attention to them.

[1] Schroedinger, E., "What is Life? The Physical Aspects of the Living Cell" (Cambridge, 1944).
[2] Riley, H. P., *Cytologia*, **7**, 139 (1936).
[3] Catcheside, D. G., *Biol. Rev.*, **20**, 14 (1945) (a recent summary received since the above was written differs somewhat).
[4] Baranetzky, J., *Bot. Zeit.*, **38**, 241 (1880).
[5] Manton, I., and Smiles, J., *Ann. Bot.*, New Series, 7, 195 (1943).
[6] Manton, I., *Amer. J. Bot.*, in the press (1945).

ALESSANDRO VOLTA, 1745–1827

By ENG.-CAPT. EDGAR C. SMITH, O.B.E.

TO few men of science has more homage been paid than to the Italian physicist Alessandro Volta. In his life-time he was received into the highest scientific circles, and the centenary of his most important discovery and the centenary of his death were the occasions of great international gatherings in the land of his birth. Since then, through the munificence of Signor Somani, Como, where Volta was born and where he died, has been enriched with a beautiful Volta Temple, a finely designed circular hall surmounted by a dome. This interesting building stands in the public gardens near the edge of a lake in Como, from which can be seen the waters, the fields and woods and the mountains amidst which Volta grew up, a student and a sportsman. For centuries the family from which he sprang had been associated with the district, and its coat-of-arms consisted of a vault (in Italian, *volta*) of a silver gate on a blue background.

Volta was born on February 18, two hundred years ago, being the son of Philip and Madeleine, descendants of the family of the Counts Inzaghi. Well educated under the supervision of an uncle, Volta began experimenting in electricity as a youth, and electricity remained his one and only love. Thanks to the invention of friction electric machines and the Leyden jar, and to Franklin's epoch-making discoveries, there were scores of devotees to the study of electricity, and during the eighteenth century thousands of new experiments were performed and a mass of observations full of promise was accumulated. In the last year of the century, it fell to Volta to make one of the most fruitful inventions in the history of science. As a young man, he corresponded with such able experimenters as Giovanni Battista Beccaria (1716–81) and the Abbé Nollet (1700–70), and in 1769, at the age of twenty-four, published his first paper. In 1774 he became superintendent of schools in Como, in 1776 professor of physics there, and in 1778 professor of experimental physics in the University of Pavia, which remained his headquarters for the rest of his active career. Those early years had been marked by the invention of his electrophorus, and the suggestion of a method of long-distance signalling by electricity. But more important in his own development were his travels, during which he made a host of friends and acquaintances, and, especially in Great Britain, became familiar with the leaders in scientific thought. In 1777 his journeys took him to Germany and Switzerland, during which he met a kindred spirit in de Saussure; in 1781 he went as far afield as Belgium, Holland, France and England; and in 1782 he was in England again, and then went to Austria. In England he admired the pavements of London, the steam engines in Shropshire, and the mills at Manchester; at Portsmouth he visited the fleet under Admiral Howe. He became known to Franklin, Watt, Priestley, Laplace, Lavoisier, Van Marum and many other famous leaders in science.

Living in London at that time was Volta's countryman Tiberias Cavallo, who had come here to follow a commercial career but had succumbed to the fascination of sparks and discharges, and had published "A Complete Treatise of Electricity". To Cavallo, Volta in 1793 addressed two letters which appeared in the *Philosophical Transactions* under the heading "Account of Some Discoveries made by Mr. Galvani of Bologna, with Experiments and Observations on Them". Behind this title lay a long series of trials with metals and the nerves of not only frogs, but also of quadrupeds, birds, fishes, reptiles and amphibia. Desiring to experiment on the human body, he used a piece of tinfoil and a silver spoon separated by his tongue, thus introducing an experiment which untold numbers have repeated.

In 1791 he had been made a foreign member of the Royal Society, and the Society now proceeded to honour him with the Copley Medal, Sir Joseph Banks in his address remarking, "The experiments of Professor Galvani, until commented upon by Professor Volta, had too much astonished, and perhaps, in some degree, perplexed many of the learned in various parts of Europe. To Professor Volta was reserved the merit of bringing his countryman's experiments to the test of sound reasoning and accurate investigation. . . ." Just at that time Europe was in the early throes of one of her periodical upheavals, and it was partly this which had led Volta to send his memoir to London.

Seven years later came a much more important paper in the form of a letter of 8,500 words in French to Sir Joseph Banks, which ultimately appeared in the *Philosophical Transactions* under the title "On the Electricity Excited by the Mere Contact of Conducting Substances of Different Kinds". The effect of this communication was as startling as the announcement of Röntgen's discovery of fifty years ago. The whole scientific world became agog with galvanic piles, batteries, 'crowns of cups' and so forth. For the first time electricity could be obtained in steady and continuous currents, and so was marked an era in electrical science. The fellows of the Royal Society having been enlightened, the members of the Royal Institution, just founded, of course had to be told; but unfortunately Dr. Garnett, not long engaged as "lecturer and scientific secretary and Editor of the Journals", made a slip and ascribed the invention of the pile to the French; Rumford heard of this, and on May 29, 1800, wrote to Banks: "I knew nothing of the matter until it was too late to prevent a mistake. I have, however, insisted on its being rectified as far as it is possible in some future lecture. . . ." Next day he wrote again that Dr. Garnett is perfectly ready to atone for his lapse and will make this declaration: "Having by mistake on Wednesday, in the course of my public lecture, ascribed to the French philosophers a new and important discovery relative to galvanism, which on inquiry I find belongs to Professor Volta of Milan, I feel it my duty . . ."

The old records are eloquent of the enthusiasm about the new apparatus, and fifty years later J. D. Forbes wrote: "The invention of the pile may in many respects be placed on a par with that of the steam engine. The results of the former were indeed more interesting immediately to pure science, the latter to the arts of life and the needs of civilization. Yet after half a century, this distinction can hardly be drawn with severity. The rapid pace of steam is insufficient for our needs. The electric wire conveys to its destination, ere the locomotive has time to start on its journey, tidings of joy and sorrow—life and death—of victories won, and kingdoms lost."

In the last year of the dying century, Volta was at the height of his career, a conqueror of Nature. In his native land was another conqueror, Napoleon, who in June won the battle of Marengo and so became master of northern Italy. Next year the two met in Paris. On November 11, 1801, Count Rumford wrote to Sir Joseph Banks, "At the last meeting of the mathematical and physical class [of the National Institute] the First Consul came in. . . . He stayed about an hour—till the meeting was over. Volta read a paper on Galvanism and explained his theory of the action of the voltaic pile or battery. . . . After Volta had finished his memoir the First Consul demanded leave from the President to speak, which being granted, he proposed to the meeting to reward M. Volta with a gold medal, and to appoint a committee to confer with M. Volta on the subject of his experiments and investigations respecting galvanism, and to make such new experiments as may bid fair to lead to further discoveries. He delivered his sentiments with great perspicacity and displayed a degree of eloquence which surprised me. . . ." Volta eventually got his medal and also a sum of money, and was elected a member of the Institute. Later, he became a senator of the Kingdom of Lombardy and a Count, but the world of science was enriched by no more discoveries by him.

Volta continued to work quietly at Pavia until 1819, when after acting as director of the Philosophical Faculty of the University for four years, he retired to his beloved Como, where he died on March 5, 1827, at the age of eighty-two. Up to the age of forty-nine he had remained a bachelor; then he married Teresa Pellegrini, by whom he had three sons. His grave and monument are at Como, where at the great Exhibition held in honour of his memory in 1899 a fire destroyed a great deal of his original apparatus.

One of the best recent accounts of Volta and his work is contained in illustrated articles by Mr. Frank Walker in *Engineering* of January 1938.

CORROSION OF METALS IN SOIL

THE corrosion of metals buried underground is a problem of very considerable importance; it is one also of great complexity. In 1922 experiments were initiated by the U.S. National Bureau of Standards to determine the effects of various soils on materials in general use for pipes buried in the ground. From time to time reports have been issued summarizing the results obtained as the work progressed; a report has now appeared dealing with an investigation begun in 1932 to study the corrosion-resistance of both ferrous and non-ferrous materials and the effect of applying improved protective coatings*.

No attempt was made to obtain series of specimens differing step-wise from each other. Manufacturers were invited to submit specimens which they believed or hoped would be resistant. Hence the various samples differed in so many ways that co-ordination of the results is a matter of extreme difficulty. The authors have themselves realized this, and deal with their data in a thoroughly sound and logical manner. They give warning that the results must be interpreted with care partly in consequence of the difficulty of obtaining satisfactory 'repeat' results, and also because the experimental conditions were not identical with those to which pipes would probably be subjected in practice. This latter point is particularly true when protective coatings are applied, because small laboratory specimens can be more carefully coated and handled with greater care than is possible in practice. As a result, when the authors attempt to arrive at a general conclusion of importance, it is so whittled down with exceptions and provisos as to be of disappointingly limited value. Although the detailed results will be of great value to the manufacturers who supplied the materials and upon whose behalf the research was, of course, mainly carried out, it is obviously the general conclusions that will appeal most to European readers.

Fifteen different soils were chosen, including several clays and loams, peat, muck and cinders.

* Soil-Corrosion Studies, 1941: Ferrous and Non-Ferrous Corrosion-Resistant Materials and Non-bituminous Coatings. By Kirk H. Logan and Melvin Romanoff. *Journal of Research*, Nat. Bur. Stand., 33, No. 3 (1944).