Scaphiopus has been studied. Moreover, Scaphiopus possesses certain exclusively individual characters. Thus the Nobelian viewpoint, that in the order of evolution, Megophrynæ occupies the lowest while Sooglossinæ the highest rungs, is questioned. The author suggests that the three sub-families Megophrynæ, Pelobatinæ and Sooglossinæ are all of equal rank and they have moved on parallel lines.

The Atomic Nucleus.

[Prof. Born first explained how he had chosen to talk about the nucleus although his main line of work was not nuclear structure: the intimate touch with the pioneers in nuclear Physics, which he had during his stay at Cambridge, was influential in his choice. Incidentally he referred the audience to his new book *The Restless Universe* with its novel illustrations which produced the same impression as a cinematographic picture when the leaves of the book were rapidly turned over. The lecturer then proceeded to give a very lively discourse on the discovery and investigation of atomic nuclei.]

THE view that an atom consists of opposite electric charges concentrated at a great distance from each other and not uniformly distributed throughout the atom was put forward by Lenard in his theory of dynamides, long before Rutherford proposed the nuclear theory of the atom. The idea behind the attempts to unravel the mystery of the nucleus was to pierce it by swift particles and thus gain a knowledge of its contents just as a closed mechanism has to be taken to pieces in order to lay bare its inner details. The discovery of Radioactivity had placed such swift projectiles in the hands of the physicist. The radioactive elements like Uranium, Polonium and Radium emit three different kinds of radiation which were named α-, β- and γ-rays. The α-rays consist of helium atoms which have lost two electrons, the β-particles are swift electrons and the γ-rays are waves like X-rays but of higher frequency. It was natural that Rutherford who had done important work in Radioactivity should study the effect of bombarding different substances by means of α-particles. It was also natural that one of the best means of studying the tracks of these particles, *viz.*, the Wilson cloud chamber should have been invented in England which is famous for its fog. When a sudden expansion is caused to take place in a chamber saturated with water vapour, the fall of temperature produces supersaturation and the vapour will condense into drops wherever some dust or charged particles are present. Since the α-particles are heavy projectiles with high energy their path is thickly studded with charged ions and droplets forming on these show the track of the α-particle as a thick straight line. Just as the projectiles from a heavy gun spread swift destruction thickly along their path while the bullets from pistols produce here and there a chance casuality and are also more easily turned from their course, the β-particles in contrast to the α-rays, produce zig-zag tracks sparsely covered with droplets. The γ-rays, on the other hand, first produce electrons along their path and the tracks of the latter then show up the passage of the γ-rays.

The experiments of Rutherford on the scattering of α-particles showed that these particles were generally deflected by small amounts, but now and then there occurs a very large deviation. Rutherford saw that such a deviation was like the passage of a comet round the sun and applying a similar calculation he was able to deduce the distance to which the α-particle had approached the positively charged part of the atom in order to suffer such large deflections as were observed, and found the distances to be sub-atomic.

The periodic system of the elements assigns to each element a number denoting its place in the table called the atomic number. This was now identified by Mosely to be identical with the positive charge on the nucleus. The simplest nucleus is that of hydrogen having unit charge and is called the proton. The other charges are multiples of these but the chemical atomic weights of the various atoms are not exact multiples of the weight of a proton. The explanation was furnished by the work of J. J. Thomson on positive-ray parabolas and the refinement which Aston introduced by designing his mass-spectrograph. This work showed that the masses of the different atoms were really integral multiples of that of the proton, thus reviving Prout's hypothesis. The chemical atomic weights were shown to be different from integers because the chemical elements are mixtures of atoms of different mass but with the same charge. Such atoms occupy the same place in the periodic table and are called isotopes. The separation of isotopes is very difficult; but in the case of the most interesting isotope, *viz.*, the heavy isotope of hydrogen discovered by Urey (for which he obtained the Nobel Prize) has been separated, with the help of its most important compound: heavy water. G. Hertz has also succeeded in separating the isotopes of neon and of hydrogen by repeated diffusion through a large number of porcelain vessels connected to diffusion pumps. Prof. Born had seen his apparatus filling a large room and witnessed its working.

Starting from the nuclear model of the atom, Bohr assumed that the electron, *e.g.*, in the hydrogen atom was revolving round the nucleus but it could do so only at definite distances from the centre so that its angular momentum changed from one position to another by integral multiples of h—Planck's constant—and that the difference in the energy when an electron jumped from one orbit to another was radiated as a single quantum $h\nu$ of frequency ν. Bohr was thus able to explain Balmer's formula for the lines of hydrogen and to deduce the constant occurring in it with great accuracy. He elaborated his theory further by the correspondence consideration that in the limit, classical theory and quantum theory should lead to the same result but there were a number of difficulties which were only removed by the Quantum Mechanics of Heisenberg and Schrödinger. According to this we no longer think of the electron as actually describing an orbit, but the orbits of the earlier theory with some modifications are the loci of the most probable positions of the electron. The quantum mechanics was also very successful in explaining how radioactive atoms send out quite by chance a particle now and then, though nobody can predict whether a particular atom is going to explode now or a hundred years hence. The explanation was offered by Gamow and by Gurney and Condon. The constituents of the nucleus have to overcome a large resistance due to their mutual attraction if they are to come out. According to classical ideas, they can never come out if their energy is less than that required to overcome this opposition while actually those that come out are shown by experiment to have an energy less than this. Taking the analogy of bodies within a crater wall, we see that they can fall outside the crater only if originally they were at a greater height. But if they were waves a certain fraction of the waves would pass through the wall as sound waves do, and if we assume the wall to become thinner at the top, waves passing near the top would penetrate easier. In a similar way the quantum mechanics associates the particles inside the nucleus with waves which have thinner barrier to pass through the larger of the energy particles and thus the fraction of these particles which comes out is the larger, the greater their energy. This is the explanation of the Geiger-Nuttall law in Radioactivity.

Further progress in our knowledge of the nucleus came from the work of Rutherford who bombarded Nitrogen with α-particles and showed that hydrogen was given out. Recent improvements in technique have enabled Cockroft and Walton and Lawrence to produce artificial missiles which disrupt a number of nuclei. Here again theoretical calculations by Gamow according to quantum mechanics showed first the possibility of breaking up the nucleus even with missiles having lower energy than the binding energy of the constituents of the nucleus, if the missile itself is caught by the nucleus.

The discovery of neutrons *i.e.*, uncharged particles of the same mass as the hydrogen nucleus (proton) by Curie and Joliot and Chadwick cleared up a number of difficulties associated with the previous assumption that nuclei consist of protons and electrons. These neutrons do not produce tracks in a cloud chamber and they cannot be stopped by large thicknesses of such heavy metals as lead. But peculiarly enough they are absorbed by light substances rich in protons such as paraffin, and the protons which they dislodge can then be studied by means of their tracks and yield information about the neutrons. Heisenberg has developed a general theory of nuclei assuming them to contain only protons and neutrons and assuming a general expression for their interaction. Further advance is to be sought in a satisfactory theory of β-decay. In course of trying to explain the fact that in β-decay electrons of all energies are sent out and not merely discontinuous groups, Pauli suggested that along with the electrons uncharged particles of very small mass called neutrinos are emitted along with the electrons, and Fermi has developed this theory to a large extent. Interesting experiments have been made at Cambridge to detect these neutrinos. They may possibly be capable of penetrating miles of lead.

Another discovery foreshadowed by theory is that of the positron. Dirac had propounded a theory of the electron which showed that positive particles of similar mass should exist. Examining the "showers" of particles produced by Cosmic radiations, by means of a Wilson chamber placed in a magnetic field, Anderson detected electron tracks curved in opposite ways. By placing a sheet of lead across the chamber and finding on which side the energy decreased resulting in greater curvature of the path, he was able to demonstrate that the particles producing both classes of tracks were moving in the same direction and therefore opposite curvature indicated opposite charge. This proved the existence of positrons and also showed that a γ-ray produces an electron-positron pair. Thus matter has been created out of radiation as definitely proved later by Curie and Joliot. The reverse of this, namely, the annihilation of an electron-positron pair resulting in high frequency γ-radiation has also been observed.

Lastly must be mentioned the discovery of artificial radioactivity by Curie and Joliot, for which they have recently obtained the Nobel Prize. These observations give fresh information about the stability of the nuclei. But just at the present moment the definite structure of the nucleus is not yet known and much further progress will have to be made before the question is finally settled. We must find an explanation, for example, for the spins of nuclei, the spin being an important property in itself, but of special interest to the audience owing to the fact that Prof. Venkatesachar and his collaborators were engaged in its investigation. Further the magnetic moments of nuclei have to be interpreted in terms of the moments of the neutron and the proton; the latter has been experimentally found by Stern to be 2.5/1840 Bohr Magnetons. However, said Prof. Born, this progress may be achieved in a short time, and with this expression of hope, he concluded his most interesting address which had kept a mixed audience of students and scientists spell-bound throughout the hour elapsed during its delivery.

T. S. S.