CHAPTER V

THE RIDDLE OF THE UNIVERSE: MATTER, SUN, WORLD, LIFE

If we believe that both matter and energy are indestructible, then we are forced to accept the view that the matter and energy of which we are made, existed when all the matter constituting the sun, the stars and their respective planets was in the state of a gas. This is a bewildering thought. We shall now attempt to picture how this matter became so arranged as to give rise to the earth and its atmosphere, how that atmosphere has gradually changed in composition through the advent of life upon the earth, and furthermore how energy radiated from the sun has been shown to be capable of causing certain gaseous substances to react to form chemical products which formerly were considered possible only through the agency of living matter. For this purpose, we must keep in mind that matter can exist in either the solid, liquid or gaseous states depending on the temperature and pressure to which it is subjected; that the spectroscope has revealed that the sun and stars contain the same elements as the earth; that there exists a gravitational force between any two masses, the greater attracting the smaller; and that the atmosphere enveloping the earth extends not more than a few miles beyond the earth's surface. Beyond this atmosphere no gaseous matter exists. The earth is, indeed, enclosed in a vacuum.

It is highly probable that the matter now forming the sun, stars and planets was once in the form of a gas extending throughout all space. Such a state of affairs must have prevailed if ever matter had been subjected to an extremely high temperature. On gradually cooling, the gas condensed into molten masses of varying sizes, probably passing through an intermediate aggregation of condensed vapour in which vast pressure existed. The larger aggregates, such as the sun, on account of their size would tend to undergo cooling at a much slower rate and therefore to remain in an incandescent state, in equilibrium with an envelope of the more volatile components of matter still remaining in the gaseous condition. Something of this kind appears to be the present condition of the sun and there certainly exists a gaseous atmosphere around it stretching for millions of miles into space. The layer in immediate proximity to the sun, called the photosphere by the astronomer, is responsible for most of the sun's luminosity. Surrounding the photosphere is a somewhat cooler gaseous envelope of between 500 and 1,000 miles in depth, which imparts to the sun a haziness. Two further layers, the chromosphere and the corona respectively, have been observed. Spectroscopic examination of the constituents of the chromosphere, carried out during eclipses of the sun and its two innermost envelopes, have revealed that it is chiefly glowing hydrogen and outward gushes of glowing calcium vapour. These gushes appear as colossal red flames. An idea of their immensity and their appalling speed may be obtained from observations made during the solar eclipse of 1919, when one of them was seen to soar through a distance of about 400,000 miles in less than 7 hours, i.e., at a speed of 60,000 miles per hour. The corona is a much cooler layer, which, in consequence of a falling-off in its heat intensity, causing a diminution in its incandescence, is not susceptible to spectroscopic examination in its outer zone.

Calculation points to a temperature of 5000° to 7000°C. as that of the photosphere. The sun's interior is therefore very much hotter. Any matter subjected to such temperatures would certainly pass into the gaseous state if ordinary atmospheric pressure prevailed. Very great pressures, however, would tend to prevent such a change from taking place. As there are no means of obtaining any idea of either the temperature or pressure existing within the sun, though both are probably very high, no guess can be made as to the precise condition of its interior.

The smaller accumulations of vapour would lose their heat in comparatively short time, and would therefore undergo greater changes in physical state than would the larger condensed masses. For this reason, it is likely that millions of small solidified bodies were being hurled through space at a much earlier period than that at which the planets acquired the solid condition. Many of the smaller heavenly bodies are clustered together as nebulæ. It is a surprising fact that the space surrounding the planets has been cleared of the smaller bodies, probably through the considerable gravitational forces which the planets have exerted on the smaller bodies that happened to come within effective distance of them. If this be the case, then these bodies must have been attracted to the surface of the attracting planet.

At the present time, there is really no satisfactory hypothesis to account for the evolution of the earth from the primitive vapour state. One view is that the matter of which the earth is composed might have been drawn out of the sun in the form of a gaseous filament as the result of the force of attraction exerted by a large star while passing in the vicinity of the sun. This filament on travelling into space cooled, solidified and moved round the sun in an orbit in consequence of the gravitational attractive force impressed upon it by the parent body. Another theory is that there was formed a ring of meteorites composed of rocks and iron moving round the sun in the orbit of the earth. As before, the matter comprising these meteorites is considered to have been originally disrupted from the sun through the effect of a neighbouring star. Collisions of these meteoric bodies thereafter occurred causing them to resolve themselves into one large sphere. These collisions caused sufficient heat to be generated to melt the superficial matter. It is a remarkable fact that the composition of blast furnace slag which floats upon the surface of the iron is similar to that of the original surface or igneous rocks. Subsequent collisions of meteoric bodies at the surface of the growing earth, not only would have generated more heat, but would have compressed the layers already laid in position. The following diagram conveys some idea of the modern picture of the constitution of the interior of the earth. The core is supposed to be iron forming a sphere of 2,200 miles radius and occupying, therefore, about one-sixth of the earth's volume. The specific gravity of this iron is stated to be 11·6, which shows that it is one and one-half times heavier, bulk for bulk, than ordinary iron. The reason for this is considered to be due to the compression caused by the weight of the outer layers. Surrounding this core is a transition layer, 800 miles thick and one-quarter of the volume of the earth. The lower zone of this layer is chiefly iron, whereas the upper zone is mainly silicates. The outer layer, of 1,000 miles depth and having a volume equal to three-fifths of that of the earth, is made of silicate material similar to that of ordinary rocks. In all probability, this layer was once in a molten state. On cooling, crystalline rocks began to separate at the surface, the heavier of which probably sank through the molten layer to a distance of about 50 miles when a higher temperature was reached, sufficient to melt them once again. This explains the

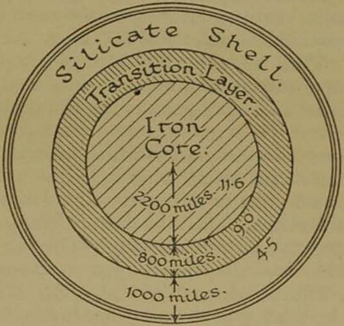

FIG. 13.—Cross-Section of the Earth.

origin of basaltic rocks which are not crystallised, and which probably still remain in the form of a hot glass. It is very probable that the conditions of temperature and pressure prevailing below a depth of 50 to 75 miles are such as not to allow of crystallisation taking place. Above the basaltic shell, a crystalline crust of granite gradually appeared. During this process of crystallisation of the exterior layer, the more insoluble, and incidentally heavier bodies were the first to separate. Thus metallic sulphides, magnetite, hornblende and olivine crystallised first, separated and sank to accumulate in deeper parts of the still molten layer. This rendered the layer nearer to the surface richer in the lighter siliceous matter, which on crystallisation gave an outer shell much richer in felspar and quartz. The first solid crust of the earth, constituting the so-called igneous rocks, was therefore of granite.

Why does the sea contain salt ? This is a question often asked and the theory just outlined of the evolution of the earth enables a plausible explanation to be made. It happens that when the surface of the earth was in the molten condition, the atmosphere enveloping it contained such gases as water-vapour, chlorine, hydrocloric acid gas, carbon dioxide, carbon monoxide and some nitrogen. It is fairly certain, however, that the primordial atmosphere contained no free oxygen, it being combined with the elements, silicon, aluminium, iron, calcium, etc., present in the earth. In a dry atmosphere, granite melts between 1300° and 1500°C., but when in the molten state, granite is capable of absorbing much water vapour and then can be cooled to a much lower temperature, about 800°C., before solidification sets in. Gradual cooling caused condensation of water-vapour in the form of clouds which, acting as a blanket, tended to protect the earth's surface from sudden changes of temperature. The soluble gases, hydrochloric acid gas and chlorine, became dissolved in the condensed water vapour, which when the earth's surface had sufficiently cooled, fell upon it as heavy acid rains. These acid rains attacked the igneous rocks then comprising the uppermost stratum and liberated the element sodium from them in the state of chemical combination with the element, chlorine, contained in the acid. Sodium and potassium, whilst found in such rocks as sandstone, limestone and shale, are present chiefly in the igneous rocks, where they exist in combination with the oxides of silicon and aluminium. The average amount of each of these elements in igneous rocks has been estimated at about 3%. Greater amounts exist in felspars. Thus potash felspar contains 12·8% of potash and 2·3% of soda, and the various soda lime felspars, e.g., lapis lazuli, may contain from 10% to 23% of soda and less than 1% of potash. Much sodium and potassium has passed into solution merely by the weathering of igneous rocks.

There is evidence that the ocean has become richer in salt, though it is still far from being a saturated solution. The total solids contained in sea-water vary from 1% to 4%, those in the Altantic Ocean ranging from 3·301% to 3·737%. The solids dissolved in sea-water are mainly common salt or sodium chloride and comparatively small quantities of potassium, magnesium and calcium chlorides, calcium sulphate and carbonate and traces of bromides.

Someone has calculated that the sodium present in the sea could have been derived by the weathering and attack of the igneous rock shell to a depth of 2,300 feet.

Numerous dry beds of ocean salts are scattered throughout the world. The order in which the various crystalline salts separate from sea-water on continued evaporation compares with that of the strata of the various saline deposits which lie below the surface clay and limestone that extend over an area of about 100 square miles around Stassfurt in Prussian Saxony. Here calcium sulphate forms the basal stratum as gypsum, $CaSO_4, 2H_2O$, and anhydrite, $CaSO_4$. Above this, a vast bed of rock salt, NaCl, exists, and superimposed upon this are several thin strata of crystalline salts composed of either potassium sulphate or potassium chloride and the sulphate or chloride of magnesium or calcium. The potash salts which are thus found associated with sodium chloride deposits contribute considerably to the natural mineral wealth of Germany, in that she holds a large proportion of the world's supply of potash fertilisers. Potash beds of lesser importance occur at Wittelsheim in Alsace and in Austrian Galicia.

Fortunately deposits of rock salt are more widely situated. Common salt is one of the essentials of life. In the first place, it is an essential adjunct to food, in that it is from the salt taken in one's diet that the 0·1% of hydrochloric acid contained in the gastric juice is obtained. For this purpose alone, a human being requires to take 16 to 17 lbs. of salt each year. In the second place, it is from sodium chloride that sodium carbonate and sodium hydroxide are manufactured; products which in turn enter into the production of many of the necessities of life. In

England, rock salt deposits exist in Cheshire, Lancashire and Worcestershire. The Cheshire salt-beds cover an area 10 miles by 16 miles. At Northwich, there are several strata of salt separated from one another by strata of marls. The first lies at a depth of about 140 feet from the surface and has a thickness of 75 feet, whilst below lies a marls stratum of 75 feet and then another salt layer of 100 feet in depth. Perhaps the largest salt bed is that of Wieliczka, in the Carpathians, which is 500 miles long, 20 miles broad and 1,200 feet deep. It has an annual output of 55,000 tons of salt.