us to choose the better part. If we would avoid the pain of compulsion, we must freely choose the better part for ourselves. So long as we halt between two, and waver this way and that, we must not expect, we dare not hope, to escape the trials which will make us of a single heart and an undivided will. When those trials come, let us remember for what they come, what an end of mercy, that so we may be able to rejoice in tribulation itself, knowing that by tribulation God is constraining us to bring forth all the peaceable fruits of righteousness and love.

S. Cox.

GENESIS AND SCIENCE.

Introductory Note.

Three eminent men of science[1] have, at my request, furnished me with their opinions as to the possibility of establishing an agreement between the statements in the first chapter of Genesis and the certain and well-ascertained results of modern scientific investigation.

I am glad to say I have their permission to publish the papers and letters in which these opinions are expressed, and they now appear as an appendix to the "Notes on Genesis" in successive numbers of The Expositor.

J. J. Stewart Perowne.

Professor Stokes on Genesis.

I.

Dear Mr. Dean,—

Some of the questions you ask me are rather for a theologian to answer than for a scientific man, especially one who does not know Hebrew. I think perhaps I had best, in the first instance, mention what on scientific

[1] Sir G. G. Stokes, M.P., F.R.S., President of the Royal Society; Rev. C. Pritchard, D.D., F.R.S., Savilian Professor of Astronomy in the University of Oxford; Rev. G. Bonney, Sc.D., F.R.S., Professor of Geology in University College, London.

grounds seems likely to have been the history of the earth, and then refer to your specific questions.

Huggins' discovery of the gaseous nature of many of the nebulæ has revived the belief in the probable formation of stars by the gradual condensation of matter previously disseminated in an attenuated form. In different nebulæ and stars we seem to see successive stages of condensation. First, we have a nebula without, or almost without, a stellar point, the spectrum of it showing that it was not solid or liquid matter, but matter in a gaseous, or it may be ultra-gaseous state. Then we have a mixture of the two, a nebula with spectrum indicative of gas, and one or more stellar points, which seem to be so connected with the nebula as to render it very improbable that they are stars having no relation to the nebula, but are merely situated casually in a line with it as seen from the earth. Then we have nebulous stars, where the stellar point forms the chief part of the whole. And, lastly, which is the commonest case, stars without sensible nebulosity.

Now here we seem to have regular gradation, beginning with incandescent gas, or ultra-gas, and going on to a definite star, that is a distant sun.

The luminosity of the nebulæ leads to the inference that the ultimate molecules are in a state of internal agitation. This is continually being spent by communication to the ether, and would cease before long if not renewed. Its renewal we attribute either to the vibrations consequent on chemical combination, or those resulting from collisions which do not eventuate in chemical combination, but leave the molecules free after encounter as they were before. In either case we look on the internal vibrations which are the source of the light as a result, and we are led therefore to the contemplation of a possible still earlier condition of things, in which the ponderable matter would exist, but would not be luminous, and in which therefore, if all the

matter in it were in that condition, the universe would be without light. It may be that in the interstellar spaces, or outside nebulæ, there is still matter in this condition; but if so, our senses give us no means of ascertaining its existence. The production of light would be therefore the first visible stage of progress. The sources of this light, instead of being concentrated into brilliant suns, would be diffused over gigantic spaces.

If we fix our attention on any one nebulous system in process of condensation, and suppose the initial motions of its parts,—the motions, that is, at a time which we please to take for our starting point, arbitrary,—then the chances would be infinity to one that the mass, as a whole, would have a motion of rotation. Into the precise mathematical meaning of what I have thus expressed in short compass I need not enter. It might well therefore be that, as the contraction proceeded, portions of the matter would, from time to time, be left behind by the retreating mass, gravitating towards it, but being prevented from falling into it by their tangential velocity, causing them to go round the central mass like an assemblage of minute planets, which would, as a general rule, collect into a single mass. Or rather, perhaps the ring of gaseous matter left behind by the contracting gaseous matter within would collect into a still gaseous mass, circulating like a gaseous planet not yet condensed, and the condensation would be subsequent to the collection. Such a mass on cooling and contracting might similarly in the process of condensation leave rings behind which would collect into satellites. In the case of Saturn we seem to have, not only a set of satellites, but also a ring of matter which condensed into a number of minute discrete bodies, instead of one, forming a ring which is in reality composed of a number of rings, instead of a single globe, or a succession of such globes.

Take now one of these primaries, say the earth. If it

condensed from nebulous matter, it would at first be at an extremely high temperature. Arguments have been derived from the figure of the earth, that it was originally in a state of fusion. Among the constituents of our earth we have a large quantity of water, some two-thirds of its surface in its present state being covered by sea, with an average depth say of two miles. While the earth was still extremely hot, this would be in that sort of nondescript condition, above the "critical temperature" of Andrews, in which, as Andrews showed, there is a continuous passage from what everybody would call liquid to what everybody would call gas, *i.e.* steam. There would be a continuous transition in the condition of water-substance from a very dense state at the surface of the earth to a rare state high up. At the outskirts of the atmosphere the temperature would, at least after a time, be below the "critical point," and there would be a mantle of cloud.

On further cooling, the surface of the earth would get below "critical point" for water. I do not recollect what this temperature is, but it is far above the boiling point. When the temperature had fallen below this, there would be a definite upper surface to liquid water, above which we should have a mixture of air and vapour of water, which in the upper region would condense and fall in torrential showers of intensely hot water. As the cooling went on, the distinction between the liquid and gaseous water would become more and more marked; the quantity of liquid water, at first small, would greatly increase, forming seas, and the temperature of the sea and falling rain would become moderate. At last the cooling might be sufficient to permit of the introduction of vegetable life. Vegetable must of course precede animal life, since all animals live, immediately or mediately, upon vegetable food.

Meanwhile the condensation of the nebular matter inside the earth's orbit would have been going on, and the

matter would come to have a stellar centre, and would ultimately collect into a sun with a definite outline. Considering the minuteness of the earth's mass compared with that of the sun, and the slowness of the condensation, it seems probable that the earth would have made considerable progress in its cooling, and what depends upon it, before the luminous matter inside its orbit would have collected into a definite sun.

The first mention we have in the record of animal life is in relation to the waters, and the earliest fossil animal remains are those of marine creatures. As to an objection which, if I rightly remember, Huxley raised, that whales are mammals, and that mammals belong to a later geological age, I do not know Hebrew, nor, I presume, does Huxley; but whatever the word may mean, it cannot, I think, mean whales. For whales are denizens of the Arctic and Antarctic seas, coming down a bit into the temperate regions; and the Hebrews in all probability knew nothing about them, and would not therefore have a word to denote the creature.[1] The word, I suppose, means some big marine creature, and the saurians are such, which stand high in geological time, though, as I do not know geology, I cannot tell you how high. Winged reptiles, which a non-scientific person might well call fowls, come pretty early. Respecting the relative order of fowls proper and mammals, I am not geologist enough to tell you. However mammals, I know, come late, and there is no evidence of anything in the way of a new form coming after man.

I do not therefore think that there is any opposition between the account in Genesis and what we learn from science, provided of course we do not insist on a slavish literalism, which I look on as a mere creation of theological

[1] I have already shown, in the December number of THE EXPOSITOR, that the word does not mean "whales," but is a general term for any kind of huge marine animals.—J. J. S. P.

fancy. On the contrary, the accordance seems to me closer than, from a theological point of view, I should care to demand.

Now for specific questions.

1. The extreme literalism which demands "day" to mean twenty-four hours seems to me to slay itself. For what we mean by day is the interval from sunrise to sunrise, or sunset to sunset; and there could be nothing of the kind before there was a sun at all.

2. The general order of succession in Genesis seems to agree with the teachings of science; but I am not aware that you can fix on definite geological periods answering one to one with the days of Genesis.

3. Difficulty in the existence of light before the sun? Answered by anticipation.

4. Meaning of "made" in the account of the fourth day. See above.

5. Creation of the earth before that of the sun and moon? As to the sun, see above. As to the moon, the less important luminary would naturally be mentioned along with the more important; and I think it is only a slavish literalism which would demand that the creation should be simultaneous because they are mentioned together.

6. Order of creation? See what was said in the first part of this letter.

I do not recollect specifically Huxley's objections; but as well as I recollect they are founded on the assumption that as theologians we are committed to what I should look on as a slavish literalism. I do not myself lay stress on the general accordance there seems to be between the account in Genesis and what we learn from science; and if there were less, it would be no particular difficulty to me.

Yours sincerely,

G. G. STOKES.

The Very Rev. the Dean of Peterborough.

Question 7. I do not see what else the "waters above the firmament" could naturally mean than the supply, whatever it may be, from which rain comes; and the commonest observation connects rain with clouds. Only a person who knew a little of science would think of invisible vapour as a source of supply.

P.S.—The above was written a considerable time ago. Since then Mr. Lockyer has put out a theory of the nature of nebulæ, according to which they consist of vast swarms of meteorites, coming constantly in collision with one another, and by the heat of collision converting small portions of the matter of which they consist into incandescent gas. This theory is still under discussion, and cannot be said to have been either accepted or rejected by the scientific world. As regards what is written above, it signifies little or nothing which theory of the nature of nebulæ we adopt.

Dec. 17*th*, 1890.

Professor Pritchard on Genesis.

I.

1. The present state of our *knowledge* indicates that the earth has cooled down after the lapse of unknown ages from a fluid or semi-fluid of intense temperature. This condition of things is without any further hypothesis as to a nebular origin.

2. If this be the case (as it *certainly* is), then at any period before the earth had cooled down to its present temperature, all *springs* would of necessity have been thermal to an extent inconsistent with the existence of any vegetation, such as we know it. Fruit trees could not have existed. This bears upon the assertion by Mr. Gladstone and others, that fruit trees existed before the sun cooled to its present normal condition.