velling to Paris for inoculation and unable to support themselves; and thirdly, a strong resolution calling upon the Privy Council to instantly inaugurate such muzzling and other restrictive measures as shall definitely and finally exterminate rabies. The anti-vivisection agitators, whose object it is, apparently, to keep alive rabies in this country, have opposed the meeting, which we hope will be crowded by genuine lovers of men and animals. The form their opposition has taken is amusing to the last degree, since it consists of a petition, advertised in the daily papers, made of four or five headings, each of which may be called in question. In the very first paragraph it is stated that the Manager of the Dogs' Home in Battersea has passed a large number of dogs through his hands, and that he never saw a case of rabies among them. If this means that there has never been a case of rabies at the Dogs' Home, we believe evidence can be produced to the contrary.

The innate falsity of this agitation is always making itself felt, and it is nothing more than Nemesis that the statements made by agitators in the hope of deceiving the public should be detected and exposed again and again. Such a statement as that asserted to have been made by the Manager, even if he did make it, has no value in view of the incontrovertible facts of the police records of the existence—nay, more, of the increase—of rabies in London. The Mansion House meeting will do much to blow away this miserable opposition, which attacks biological science alone, knowing full well that no false sentiment can be hashed up against physical science and its benefits to mankind. The object of the meeting is to honestly acknowledge our great indebtedness to M. Pasteur, to provide for our poorer fellow-countrymen gaining the benefits of the Pasteur Institute, and, finally, to stamp out rabies.

No scientific man who really has the interests—in fact, the honour—of his country at heart will refuse his support on this important occasion; and we may well hope that many will be found able to attend the meeting personally, to render the occasion worthy of the great chemist whose work has so essentially led to the successful performance of the hygienic measures now about to be executed.

STELLAR EVOLUTION.

Stellar Evolution and its Relation to Geological Time.

By James Croll, LL.D., F.R.S. (London: Edward Stanford, 1889.)

DR. CROLL'S book, though chiefly dealing with the question of stellar evolution from the astronomer's point of view, calls in the evidence afforded by geology in favour of the theory which is set forth in its pages. The particulars of the theory are clearly stated, and the new facts which have been gathered since the theory was first published are fully considered.

Dr. Croll accepts the nebular hypothesis of Kant and Laplace, and deals mainly with the question of the pre-

nebular condition. According to his theory, large cool dark bodies, moving with enormous velocities, were either created or were eternal; and these colliding with each other here and there, the evolution of the celestial bodies was accomplished. With regard to the origin of these bodies endowed with motion, Dr. Croll states:—"We are perfectly at liberty to begin by assuming the existence of stellar masses in motion; for we are not called upon to explain how the masses obtained their motion, any more than we have to explain how they came into existence. If the masses were created, they may as likely have been created in motion as at rest; and if they were eternal, they may as likely have been eternally in motion as eternally at rest" (p. 3). It is argued that the heat energy which would have been derived from gravitation alone could not possibly have been equal to that which the solar system originally possessed. But there is absolutely no limit to the amount of available energy from Dr. Croll's point of view. The most important argument against the gravitational theory is undoubtedly the geological and biological one. The whole question of geological time rests on an estimation of the time during which the sun has been radiating its heat, and on this point Dr. Croll remarks: "If gravitation be the only source from which the sun has derived its heat, then life on the globe cannot possibly date farther back than 20,000,000 years, for under no possible form could gravitation have afforded, at the present rate of radiation, sufficient heat for a longer period" (p. 35). The adoption of Langley's value (1.7 times that of Pouillet) for the rate of solar radiation reduces Helmholtz's estimate of 20,000,000 years to 12,000,000 years, and even this would not be available for plant and animal life, as millions of years must have undoubtedly elapsed before the earth was prepared for them. Prof. Tait ("Recent Advances in Physical Science," p. 175) has shown that, from the physical point of view, "10,000,000 years is about the utmost that can be allowed for all the changes that have taken place on the earth's surface since vegetable life of the lowest known form was capable of existing there." Sir William Thomson states his conclusions on this point thus: "In the circumstances, and taking fully into account all possibilities of greater density in the sun's interior, and of greater or less activity of radiation in past ages, it would, I think, be exceedingly rash to assume as probable anything more than 20,000,000 years of the sun's light in the past history of the earth, or to reckon on more than five or six million years of sunlight for time to come" ("Popular Lectures and Addresses," p. 390).

It is not necessary here to enter into details of the various methods by which geologists and biologists have attempted to estimate the length of time which must have elapsed since the earth first received the heat of the sun. On this point Dr. Croll says: "The grounds upon which the geologists and biologists found the conclusion that it is now more than twenty or thirty millions of years since life began on the earth are far more certain and reliable than the grounds upon which the physicist concludes that the period must be less" (p. 68). Here again, it may be well to quote Sir William Thomson, who says:—"What then are we to think of such

geological estimates as 300,000,000 years for the 'denudation of the Weald'? Whether is it more probable that the physical conditions of the sun's matter differ 1000 times more than dynamics compel us to suppose they differ from those of matter in our laboratories; or that a stormy sea, with possibly channel tides of extreme violence, should encroach on a chalk cliff 1000 times more rapidly than Mr. Darwin's estimate of one inch per century?"¹

But granted that the geological evidence is against the gravitation theory, it remains for us to see how Dr. Croll's theory bears the strain put upon it when the details of the evolutionary processes are inquired into.

According to the impact theory of Dr. Croll, "meteorites are but the fragments of sidereal masses which have been shattered by collision" (p. 12). The result of such a collision would be mainly to produce a gaseous mass, but some of the exterior fragments would have velocities sufficient to carry them beyond the influence of the central mass. This view is obviously in direct contradiction to the opinion held by Mr. Lockyer, who looks upon meteorites as the parents, and not the children, of sidereal systems. The explanation of the thumb-marks and the heterogeneous structure of meteorites which has been given by Mr. Lockyer (Proc. Roy. Soc., vol. xliii. p. 151) would apply equally to Dr. Croll's view.

Comets, according to the impact theory, have a similar origin to meteorites, Dr. Croll apparently agreeing that they are nothing more than swarms of meteorites. Those with elliptic orbits probably had their origin in the collision which produced the nebula out of which the solar system has been evolved, whilst those with parabolic and hyperbolic orbits are probably the outcasts of other systems.

The first condition of a nebula, according to Dr. Croll, is that in which it consists of broken fragments scattered through a gaseous mass of excessively high temperature. Mr. Lockyer's recent researches are consistent with this view, as far as meteorites and interspaces are concerned, but they point to the opposite conclusion with regard to temperature. Mr. Lockyer's spectroscopic work has shown that the highest temperature is in all probability only reached by a nebulous mass after the complete volatilization of all the meteorites composing it, and he has shown that the intermediate stages which should occur on this supposition are actually represented amongst the stars, the stars of Group II. being amongst these. This therefore furnishes a strong argument against the high-temperature theory of nebulae.

According to the impact theory of Dr. Croll, the meteorites scattered through the gaseous mass have nothing whatever to do with the luminosity; whereas, from Mr. Lockyer's point of view, the luminosity is in great part, if not entirely, due to collisions between the meteorites. Dr. Croll objects to this latter view because it "does not appear to afford any rational explanation of this banging about of the stones to and fro in all directions; for, according to it, the only force available is gravitation, and this can only produce merely a motion of the materials towards the centre of the mass" (p. 20). Dr. Croll has evidently given but little thought to this theory, originally advanced by Prof. Tait, for it is obvious that all the meteorites would not lose all their momentum

by collisions during their first movements towards the common centre of gravity. Those which escaped collision would move on beyond the centre of gravity with considerable velocities, and would continue to oscillate to and fro until all their momentum was converted into heat by collisions. The banging about might therefore go on for a very long time, and the observations made by Dunér, and classified by Mr. Lockyer, show that this is probably the case. The increase of temperature would accordingly take place gradually, and not suddenly, as Dr. Croll supposes; and further, the highest temperature would be associated with a certain class of stars, and not with the nebulae themselves.

The subject of new stars is dismissed with very few words. The general view adopted by Dr. Croll seems to be that in such a case as Nova Cygni the outburst was due to the collision of a star with a swarm of meteorites. The spectroscopic evidence in favour of Mr. Lockyer's view, that such an outburst is due to the collision between two swarms of meteorites, is not even referred to. The case of Nova Cygni, indeed, has an important bearing on theories of cosmogony. Its spectrum, as observed by Copeland when it was just fading from our view, was that of a planetary nebula. If, therefore, a nebula is at a higher temperature than a star, Nova Cygni must have got hotter as it got dimmer!

Dr. Croll shows that his theory explains other details of the structure of our universe, including the proper motions of stars and the origin of binary systems, but these need not be more than mentioned.

Assuming that Dr. Croll has established that gravitation alone would have been incompetent to produce the heat originally possessed by the solar nebula, it is only necessary to reconcile this with the low-temperature theory of nebulae, as the high-temperature theory has been shown to be inconsistent with the facts.

It may be suggested that instead of the dark stellar masses endowed with motion which Dr. Croll supposes to have been the pre-nebular condition, meteorites at great distances apart were endowed with similar velocities. In the first groupings, the collisions would only occur very rarely, and there would be more grazes than anything else, so that the average temperature might still be low in the earlier stages. Prof. G. H. Darwin¹ has recently shown that the conception of fluid pressure which is demanded by Laplace's nebular hypothesis is not difficult to reconcile with the meteoritic hypothesis. If we substitute meteorites in collision for the molecules of a gas impinging against each other, there would be a quasi-fluid pressure as the average result of the impacts of the meteorites, and the separation of the planets from the meteor-swarm would take place exactly as in a gaseous mass.

A. FOWLER.

THE TELEPHONE.

The Telephone. By William Henry Preece, F.R.S., and Julius Maier, Ph.D. Pp. i-xvi., and 1-498. (London: Whittaker and Co., 1889.)

THIS book is one of the "Specialists' Series" of technical manuals now being issued by Messrs. Whittaker and Co. Its aim is to give as full an account as possible

¹ *Macmillan's Magazine*, March 1862; reprinted in "Popular Lectures and Addresses," p. 361 (Macmillan, 1889).

¹ Phil. Trans., vol. cclxxx. pp. 1-69.