

Savilian professor at Oxford. See Keil's 'Examination of Dr. Burnet's Theory of the Earth,' page 140. It is certainly a remarkable coincidence that the school of Cassini starting with the erroneous theoretical notion that the degrees of the meridian *ought* to decrease from the equator to the pole arrived at the same result by observation and measurement.

"There can, I think, be no doubt that at least Maupertuis and Clairaut, who were the most eminent of the French party, held the correct Newtonian theory as to the figure of the earth; and their result was rather too decided in its confirmation of this theory. Now the geodetical angles could scarcely be influenced by the theoretical opinions of the observers; because it would not be obvious in what way the result would be affected by an error in an angle. But in measuring the base it would of course be obvious that the larger was the value obtained, the stronger was the evidence for an oblate form. Similarly in estimating the amplitude, the smaller the value obtained the stronger was the evidence for the oblate form. In these two parts of the survey then it would be necessary to be on the watch lest the conviction of what the result ought to be should influence the impression of what the observation really gives.

"It is curious that Maupertuis and his party seem to have thought at first that their success was too decided, and therefore their amplitude too small; and that on their second determination they should have made it between 3" and 4" larger than at first."

THE BEGINNINGS OF LIFE *

I.

AFTER a careful perusal of this important and suggestive work, a prominent feeling is one of regret that its value and popularity should be endangered owing to purely technical faults of composition and arrangement. It is so full of curious and novel facts and experiments, it contains so much excellent reasoning and acute criticism, and it opens up such new and astounding views of the nature and origin of life, that one feels it ought to and might have ranked with such standard works as the "Origin of Species" and the "Principles of Biology," if equal care had been bestowed upon it as a literary composition. But, unfortunately, it altogether lacks their powerful condensation and lucid arrangement. Its vast masses of facts are stated too diffusely, and are often so scattered as to lose the cumulative force that might have been given to them; while the arguments are broken up and weakened by a too minute classification of the subjects treated, leading to repetition and confusion rather than to clearness. Haste of composition is further indicated by the quantity of additional matter given in foot-notes that should have found a place in the text; and we often find it difficult to follow the special argument in hand, or to see the connection and relevance of much of the detailed evidence brought forward.

Notwithstanding these defects, which will undoubtedly diminish its popularity, it is a book which will make its mark, and must produce a powerful sensation.

It brings together a large body of facts, either new or hitherto almost ignored, which, unless they can be otherwise explained, prove much more than the mere production of low living organisms from dead matter; for these low forms have been seen to combine and give rise to higher forms, and these again to still higher and more complex organisms. Vegetable cells or their contents develop into various low animals; while animal as well as vegetable organisms of specialised forms and some elaboration of structure seem to be mutually transformable by processes quite unlike any of the hitherto accepted modes

of multiplication or reproduction. These processes have been traced stage by stage, so that there seems no possibility of mistake; and they do not rest on the observations of Dr. Bastian alone. Facts of this nature have been repeatedly published for more than twenty years by many Continental and English naturalists, but, being so entirely opposed to current theories, have been all silently ignored, just as true facts and careful observations relating to the antiquity of man were so long ignored. Our author has, however, repeated and tested many of these observations, and finds them to be strictly accurate; and they harmonise perfectly with the views on the origin of life founded on his own experiments, and so energetically advocated by him.

Looked at merely as curiosities of science, and as an unveiling of mysteries hitherto thought to be inscrutable, these observations are of supreme interest; while their importance in connection with modern theories of development and the origin of species can hardly be overrated. Setting aside all the prejudices and dogmas of the existing schools of biology, it must be admitted that the views here presented of the perpetual origination of low forms of life now, as in all past epochs, is in perfect harmony with the doctrine of evolution, and does away with many of the physical and geological difficulties which are undoubtedly among the most serious which beset those special views of the origin of life which Mr. Darwin holds, but which are by no means necessary inferences from his theories.

‡ The present work is essentially one that to be judged soundly cannot be judged hastily. The subject is of overwhelming importance to the future progress of scientific biology, and the facts and observations on which it is founded are so numerous and so precise, and have been tested by such a body of distinct and competent observers, that no *a priori* arguments and no authoritative dicta can have any weight against them. Observation alone can demonstrate whether they are facts or delusions. They will no doubt be fully criticised by those whose special studies render them competent to do so; but if the past history of science has any value whatever, the result cannot be doubtful. Facts observed and tested by a succession of careful and accurate observers, such as those whose evidence is adduced by Dr. Bastian, have never yet proved to be fallacies.

We now propose to lay before our readers a sketch of the more interesting matters treated of in these volumes, citing a few of the most striking of the new facts and the most important of the arguments founded upon them.

More than half of the first volume is devoted to an account of the Nature and Source of the Vital Forces and of Organisable Matters, and we have an excellent summary of modern views on the correlation of vital and physical forces, on the vital principle, on theories of organisation, and on the modes of origin of reproductive units and cells. As bearing upon subjects to be discussed further on, there is an important remark on the origin of germs or specks of living protoplasm in the fluids of the living body. These fluids, it is maintained, are not alive, and, therefore, the living germ does originate in a dead organic fluid. Even if it is held that blood and all the other secretions are alive, yet as they have been formed out of dead matter taken into the stomach there must be some point at which the particles of dead matter become transformed into living matter, and the circumstance of this occurring *within* an organism does not alter the fact of its occurrence, or render it at all more easy to conceive or explain. Why, then, should it be so absolutely incredible that specks of living protoplasm should arise in suitable fluids out of a living body? It is certain that as soon as the fact that they do so arise is established, the one will be as easy to conceive and be as credible as the other. The only other point that calls for notice in this part of the work is the discussion on the supposed "vital force," in which the views of the "vitalists" seem to be

* "The Beginnings of Life: being some account of the Nature, Modes of Origin, and Transformations of Lower Organisms." By H. Charlton Bastian, M.A., M.D., F.R.S. (2 vols. London: Macmillan and Co. 1872.)

hardly fairly stated. Dr. Bastian says:—"If the vital or directive power resident in each particle of a living being be other than a transformed physical force it must be one which—in spite of the well-known formula '*ex nihilo nihil fit*'—is capable of indefinite self-multiplication. Either such force must be continually springing into being without cause—originating itself or growing out of nothing—which is an absurdity; or else, within the ovum of any animal, there must be locked up the whole of the peculiar vital power which is afterwards to diffuse itself throughout the body," &c. But this is by no means a necessary conception of the "vital force" or "vital principle." That force or principle need not, and cannot "reside" in any particles of matter. If it exists it is cosmical, and acts *on* matter just as gravitation does. Is it any argument against the reality of gravitation that any particle of matter, however small, attracts any mass, however great; that, as Prof. De Morgan puts it, each grain of salt and pepper in a million salt-cellars and pepper-casters, individually and separately *pull*, and actually move, the sun and every fixed star? This is a *reductio ad absurdum* against the notion that the force of gravitation resides *in* matter; but it does not touch the notion of gravitation as an inscrutable cosmical force (probably the source of *all* force) acting on matter. It appears to me, therefore, that as long as consciousness, thought, and will cannot be conceived of as manifestations of the "correlated series of physical forces," we must postulate some universal "vital principle" as co-extensive with, if not superior to and the source of, the "physical forces;" and if such exists it is natural to impute to it some share in the production of these wonderful *organisms* through which alone we see consciousness manifested. In another place Dr. Bastian says that living protoplasm is believed by a large section of the physiological world "to contain no special and peculiar 'force;' but to owe its qualities entirely to the ordinary physical properties of the elements entering into its composition." It may not *contain* a peculiar force, but surely it *does manifest* some other properties than the ordinary physical properties of its elements, just as the thundercloud, when it sends out a destructive lightning flash to the earth beneath, manifests other than the "ordinary physical properties" of the oxygen and hydrogen of which it is composed. Electricity is an extra-ordinary property of matter, and *vitality* seems to me to be still more extra-ordinary. The *force* both exhibit may be correlated with other forces; but that does not account for the special *mode* in which the force is manifested in the one case more than in the other.

In the second division of his work, "Archebiosis," Dr. Bastian commences with a history of the discussion on Spontaneous Generation from the time of Aristotle to that of Pouchet and Pasteur. He then gives an outline of the evidence as to the production of low organisms in infusions. These are chiefly Bacteria and Torulæ, names which are of such frequent occurrence that we reproduce a woodcut (Fig. 1), in which they are represented, the straight objects *c* and *d* being Bacteria, while *h*, *i*, and *k* represent Torulæ; the small dots *a* are Monads, Microzymes, or plastide particles, or they may be Bacteria seen endways; while the other objects are Torula cells, or fungus germs variously combined. These are the simplest and most minute organisms; but others a little larger and more complex are shown in the next cut (Fig. 2), under the names of Vibriones, Leptothrix, Spirilla, and Mycelial filaments. These all exhibit unmistakable signs of life, growth, and reproduction, and they appear in immense abundance in a great variety of infusions of animal and vegetable matter, however perfectly they may be shut out from the surrounding atmosphere. Most experimenters have conceived that the presence of air was necessary in order to develop organisms, and with the air it has been supposed that germs or ova have been always introduced. These germs are, however, admitted

to be invisible by the highest powers of our microscopes; their very existence is therefore hypothetical, and our author shows very forcibly that Pasteur's supposed demonstration of their existence, and of their being the source of the organisms which appear in infusions, is wholly fallacious. He assumes at critical points of the argument the impossibility of his opponent's views being the true ones; and imputes his negative results to his having eliminated germs, when they can be equally well shown to be due to unfavourable conditions for development. But in order to avoid such complicated and inconclusive experiments as those carried on during the celebrated discussion between Pasteur and Pouchet, Dr. Bastian adopts a totally distinct method, which so narrows the issue as to render it possible to arrive at something like absolute certainty in the results. Instead of introducing air, purified by various chemical means, into the flasks after the infusions have been boiled, he hermetically closes their narrow necks during violent ebullition, thus producing an almost perfect vacuum above the liquid contents. After this he submits the whole flask to a heat varying from 212° to over 400° F., and then places them in favourable positions as regards light and heat. Under these rigid conditions he finds large quantities of organisms produced, which exhibit such unmistakable signs of life as growth and multiplication. Now here the issue is reduced to its very narrowest limits, viz., what degree of heat will destroy all these low forms of life; and to determine this he adduces a series of experiments, detailed in his chapter on "The Limits of Vital Resistance to Heat." M. Pasteur found that the greatest tenacity of life was possessed by the spores of certain fungi of the family *Mucedineæ*, which germinated after being exposed to a dry heat of 248° to 257° F. for a few minutes, but half an hour's exposure to the same dry heat killed them. A Commission appointed in 1860 by the Société de Biologie found that of the lower animals, the Rotifers, "Sloughs," and Anguillules found in moss, &c., were most tenacious of life, but they were all killed by a lower temperature than that above stated, so that we may fairly conclude a heat of 266° F. for thirty minutes in dry air to be the limit of vital resistance hitherto ascertained. In fluids, however, a much lower temperature suffices. Hardly any low organisms can resist 167° F., while 212° F. for even one minute is admitted by all experimenters on this subject to be fatal to all classes of organisms met with in infusions, with which alone we have now to deal. Bacteria and Vibriones, however, are killed by a much lower temperature (130°-140° F.) for ten minutes, as ascertained by a careful series of experiments; while several degrees lower was equally fatal if prolonged for four hours. It has been objected that the flasks being only partially filled, some germs or organisms may escape the liquid and survive on the sides of the glass; but as they must be exposed to almost pure steam of the same temperature as the water, and as the heat actually employed was often greater than any such organism can withstand, even in dry air, the objection cannot be held to be valid.

What, now, are we say to such experiments as the following:—Prof. Jeffries Wyman found Vibrions and Bacteriums moving with great rapidity in mutton juice which had been exposed in a hermetically-sealed flask to a heat of 120.6° C. for five minutes. Prof. Mantegazza found living Bacteria in a decoction of lettuce which had been similarly exposed for 30 minutes to 284° F. Prof. Cantoni, of Pavia, heated a solution of yolk of egg in a hermetically-sealed flask up to 242° F., and found in it after two days a large number of Vibrions. Dr. Bastian himself exposed a strong infusion of turnip in a hermetically-sealed flask to a temperature of 270°-275° F. for twenty minutes. After two months the contents were examined, and found to contain numbers of organisms, of which the annexed cut (Fig. 3) represents a specimen. Again, a solution of ammoniac tartrate and sodic phos-

phate in distilled water was heated to a temperature of 295°-307° F. for four hours. It was at first colourless and clear, and being carefully watched was found after some

days to become slightly flocculent ; a small speck then appeared, which grew for several days till it could be seen with the naked eye. On being opened and examined, the

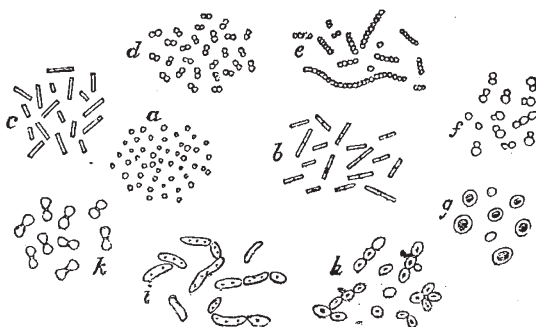


FIG. 1.—SOME OF THE MOST COMMON PRIMORDIAL FORMS OF LIFE: BACTERIA, TORULÆ, &c. (X 800)

speck was found to be the remarkable fungus represented in Fig. 4.

with the same infusion heated to different temperatures, by which it has been ascertained that for each substance there is a different maximum, if heated beyond which no

Besides this class of experiments, others have been made

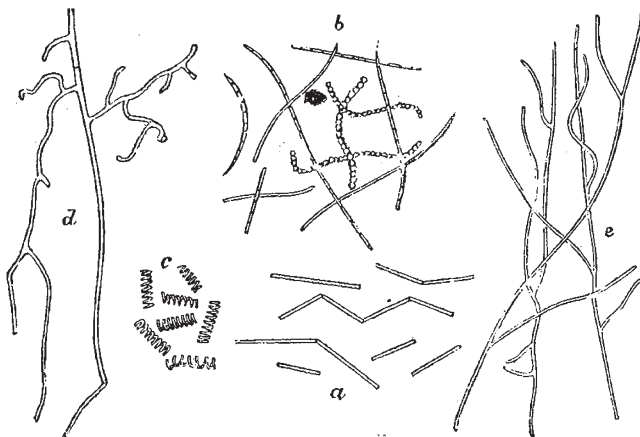


FIG. 2.—OTHER EARLY FORMS OF LIFE FROM ORGANIC INFUSIONS.

a. Vibriones. b. Different kinds of simple Leptothrix. c. Spirilla. d. Mycelial Filaments of an Incipient Fungus (Hallier). e. Branched Leptothrix or Mycelia Filaments (Pasteur).

organisms appear. The juice of meat, for instance, produced Vibrios if heated to 112° C., but none if heated to 114° C. Cows' milk produces them, if heated to 113.5 C.,

but remains unproductive if heated to 114.5 C.; while a decoction of pumpkin produces them at 110° C., and not at 112° C. Prof. Cantoni naturally asks why, if the Vibrios

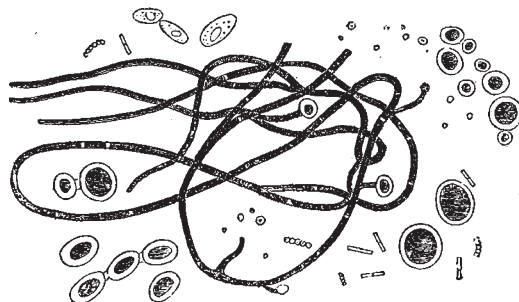


FIG. 3.—BACTERIA, TORULÆ, FUNGUS-MYCELIUM, AND SPORES OF DIFFERENT SIZES, FROM A NEUTRALISED TURNIP INFUSION (X 800).

are produced from germs, it requires such different amounts of heat to kill them in different solutions ; and why these hypothetical germs should require such a vastly higher

temperature to kill them than suffices to destroy their parents? A large number of comparative experiments made by Dr. Bastian further shows that the presence or

absence of Bacteria and other low organisms in infusions often bears little or no relation to the facilities for the admission of germs from the atmosphere, but seems to depend on a variety of special conditions only to be learnt by long practice. The temperature at which the infusion was made, its quantity, the presence of dense or rarefied air in the flask, a few degrees more or less of temperature of the room where the flasks are kept, and a variety of other circumstances, so affect the results, that in some cases organisms refuse to appear when there is every facility for the hypothetical germs to gain admission; while, as we have seen, they are often plentifully

produced when every possible precaution is taken to keep them out and to destroy them. The only way of escaping from the results of such a series of experiments as that here recorded is by asserting that, although the organisms which are produced in the flasks are killed by a temperature much below that to which the flasks have been subjected, the germs from which they have been produced are not so killed. We are asked, therefore, to accept as facts three pure suppositions: first, that such excessively minute and simple organisms as Bacteria, whose only mode of multiplication is by fission or gemmation, have germs which possess different physical proper-

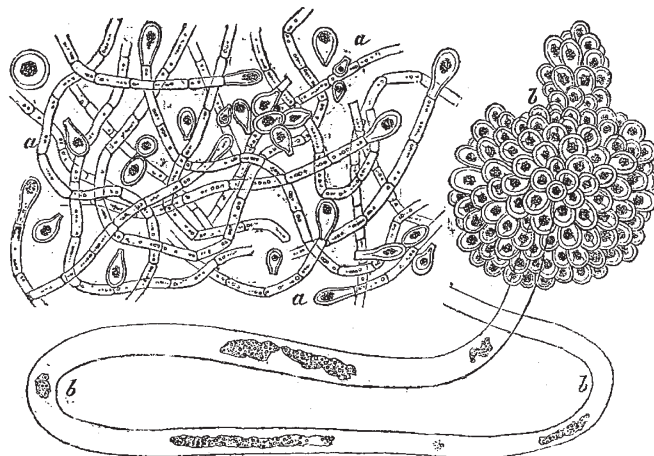


FIG. 4.—FUNGUS FOUND IN A SOLUTION OF AMMONIC TARTRATE AND SODIC PHOSPHATE (X 600).

ties from themselves; secondly, that these germs, as well as many others, are omnipresent in the atmosphere; and, thirdly, that they are not injured by an exposure for four hours to vapour heated to over 300° F.; and, finally, we are to accept all these suppositions as facts in order to avoid admitting that specks of living protoplasm are originated *de novo* in some fluids just as specks of crystalline matter originate in other fluids, and although some organisms can be seen to make their appearance in fluids independently of all pre-existing visible germs, just as crystals do.

It must, we think, be admitted that in the portion of his work we have now been considering, Dr. Bastian has fairly met and fully answered all the objections that were made to his earlier experiments. He has, moreover, shown the fallacy of many of the arguments of M. Pasteur and his supporters; and, by a series of careful and well-devised experiments, the results of which agree with those arrived at by a large number of other workers both in this country and on the Continent, has proved the *de novo* origin of various living organisms in air-tight flasks. This alone is a great step gained; but it is, as we propose to show in our next article, only the stepping-stone to more important observations and more startling facts.

DR. LIVINGSTONE

THE despatches and private correspondence of Dr. Livingstone, after a long detention, have at last been delivered, and we are now able to give extracts from the explorer's reports which throw further light on his discoveries. He appears to have ascertained, by a journey round the south-eastern side of Tanganyika, that that lake has no outlet. He has also explored the drainage to the eastward for nearly 600 miles. We learn also that his present object is to examine the hills to the south-west of Lake Bangweolo, where he had been told that there are

four fountains, which he confusedly connects with the sources of the Nile, as described by Herodotus. There is marvellous heroism in this persistency, and it is sad to reflect that the grand old traveller is doomed to disappointment. But there can scarcely be any doubt that these rivers to the eastward of Tanganyika have no connection with the Nile. Apart from other considerations, Livingstone's own observations show that his Lualaba, where he saw it, was only at the same height above the sea as Gondokoro, and the error of his instrument would increase rather than diminish the height. This makes it impossible that his discoveries can be connected with the Nile. Doubtless the mass of waters is lost in some inland swamp.

The measures for Dr. Livingstone's relief were conducted with zeal and good faith, and he is now well supplied from stores sent up by Dr. Kirk and by his son. Mr. Stanley has also done excellent service in pushing on to Ujiji, in accompanying Livingstone to Unyanyembe, and in bringing home the letters and despatches. The President of the Geographical Society, in the name of the council, has promptly and cordially acknowledged this service, and the perseverance and energy with which it has been performed, in a letter addressed to Mr. Stanley as soon as the despatches were received. There was no delay or hesitation in giving him the credit that was his due; and equal promptitude has been shown by the Secretary of State for Foreign Affairs, whose letter has already been published. But the American correspondent's subsequent conduct, though doubtless agreeable to his employers, deserves no thanks from the countrymen of Livingstone. The ungenerous attack upon Dr. Kirk is sufficiently refuted by the evidence of Dr. Livingstone's own son, whose letters will, we trust, dispell the delusions with which his father's mind had been filled. Even now we can scarcely believe that Mr. Stanley is justified in his assertion that Dr. Livingstone, the great enemy of slavery, commissioned him to send up sets of slave chains to be used by Her