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THE CONTRAST BETWEEN CRYSTALLIZATION AND LIFE. By JOHN ELIOT HOWARD, Esq., F.L.S., F.R.M.S., F.R.H.S., Memb. Pharm. Soc. and Botanical Soc. of France, &c.

IT is well known that powerful and persevering efforts have recently been made to confound the distinction between animate and inanimate matter; to represent life as merely a special form of chemical or mechanical action, and organization as the result of some undiscovered correlative of the molecular forces of nature. It has been supposed that the notion of Deity, or of an omnipotent creative and sustaining power, may be thus removed to a greater distance from the human mind; and the unwelcome thought of responsibility to a higher tribunal than those of earth, and of subjection to an eternal judgment, abolished. That so little success has as yet attended the prophets and teachers of this new doctrine, is not owing to any lack of earthly distinction attaching to the eminent names of its propagators, nor to any want of appreciation of their own merits and those of their fellow-labourers. It might almost be said that they form a mutually supporting and a somewhat exclusive sect.* But they have before them an impossible task, for though they possess abundance of intellectual resource, and could therefore hope to "make the worse appear the better reason," yet they have to overcome the impracticably *practical* character of the average English mind, and its strong common sense, to say nothing of its attachment to its cherished traditional opinions. It is not the present generation of Englishmen who will believe that life was brought down to this planet by some fragmentary disrupted portions of a ruined world; neither will they be reconciled to the thought that they are really in their origin "viler than the seaweed," and in their gradual fashioning improved out of the most lowly organized animals † that the earth and the sea support.

Works of Preceding Authors.

2. As I mean to follow out my own line of thought and

* See Appendix (*Edinburgh Review*).
† The *amœbas* and *moners*. See Appendix (C).

observation, it is not requisite that I should notice, unless very briefly, the works of others who have treated of the same subjects. It will, however, be expedient that I should, in the first place, acknowledge my obligations to an author from whom I shall take the liberty of quoting; and in so doing claim not merely as an ally, but as one who has already overcome his opponents in a well-fought field of argument. These antagonists do not seem to be exactly such as one would choose to encounter; for he says that as soon as they enter on the vital question, "they assume the tone of the advocate, of the proselytizer, of the zealot, and to such energy everything must yield—unproven and unprovable assertions have been advanced over and over again, until it becomes tiresome to notice them."

3. This is alarming, but I must hope to fare better than my predecessor, as these opponents will have learned moderation by experience of their present want of success.

Dr. Beale.

4. "The theory of vitality" has been so admirably discussed by this author, the eminent physician and admirable microscopist, Lionel S. Beale, M.B., F.R.S., F.R.M.S., that I need only say I rejoice that his (as yet unanswered) works are in possession of the Institute, so that the Fellows can verify any allusions I may make, and judge for themselves whether the highest commendation I can bestow transcends their merit. It will therefore be understood that, in pursuing my own argument, I am not at all insensible to the claims of that which has been thus incontrovertibly adduced on the right side of the question. Dr. Beale has fully proved that "creative force is as far removed as ever from non-constructing force; and the great life-mystery, in spite of the efforts and consummate skill of physicists and chemists, remains a mystery as great as when in childhood the longing first arose to inquire into the why and how."

Dr. Huxley.

5. It is necessary that I should also say a few words as to the views which Professor Huxley expounds in his "Lay Sermons." I trust that, in appealing specially to the statements which I there find, I shall not be thought to be unfairly reviving exploded dogmas. I claim to be one of "the few writers who have taken the trouble to understand the subject," and whose

views have not induced the learned Professor to withdraw his work: the fourth edition of these sermons is that from which I quote, and this edition, issued in 1872, is now, as I find, in full sale, and much sought after.

6. It is with great respect and admiration for the truth-loving character of his mental constitution, as evidenced in his works, that I name Professor Huxley. The outspoken fearlessness with which he propounds his convictions, is worthy of a better creed and of sounder philosophy. I have never listened with so much pleasure to any scientific instructor; and it is of course with reluctance that I feel compelled to differ so absolutely from his conclusions as will presently appear. He inspires his hearers with a wholesome confidence in their power to understand propositions expounded to them in well-chosen English phrases; and does not attempt the mystification which clothes learned ignorance under the specious guise of transcendent absurdity wrapped up in high-sounding Greek. Even when he verges on this objectionable course—as I think that he does in the properties which he attributes to *protoplasm*—it seems to me that the defect arises from his misconception of the nature of the subject on which he treats. In the commencement of his lecture* on "The Physical Basis of Life," he says, "In order to make the title of this discourse generally intelligible, I have translated the term 'Protoplasm,' which is the scientific name of the substance of which I am about to speak, by the words 'the Physical Basis of Life.'"

7. Now, I must be permitted, and Professor Huxley himself would specially urge it upon me, to bring this information into correlation with whatever knowledge I may previously have acquired. In the first place, then, I am dissatisfied with the word itself, since πρῶτον πλάσμα would, if I mistake not, most correctly mean "the first image," or "the first fable or fiction."† But let this pass, and take it, as I suppose is meant, as "the first thing formed." Then I have a right to inquire who or what is the *former;* and also where is the *proof* of its being the first thing formed. Professor Huxley himself, in treating of "vitality" and "aquosity," brings from amongst the imponderables the electric spark; and by means of this unites his oxygen and hydrogen to form water, the properties of which

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* "The substance of this paper was contained in a discourse which was delivered in Edinburgh on the evening of Sunday, the 8th of November, 1868, being the first of a series of Sunday evening addresses upon non-theological topics, instituted by the Rev. J. Cranbrook."—*Lay Sermons, &c.*, p. 120.

† Liddle & Scott's *Lexicon*, &c.

he truly describes as altogether different from those of the gases. Why may I not equally suppose that organization proceeds from some "*subtle influence*" working first amidst and from the essence of imponderable matter; and disclosing its presence by its effect on the albumen and oil, and whatever else may be the first scene of its operations? Are not the manifestations of electricity as far out of the range of our *à priori* conceptions as the latter hypothesis can be? Who can tell us exactly what electricity is, or (except from its effects) what is life?

8. My next difficulty is a still more serious one. The Professor having thus defined a substance which he terms "a physical basis or matter of life," goes on to describe many wonderful properties attaching to it. But to look at this matter from a chemical point of view, we must first inquire what this substance is. Is it one thing, or is it a congeries of varying material to which no homogeneous character can be ascribed,—and, still less, such attributes imputed as we soon find? A chemist, in order to form an idea of the properties of a substance, will sedulously endeavour, if possible, to isolate it from other bodies (by crystallization for instance); and when this has been effected, we have something concerning whose molecular changes we can inquire. But if we take an egg,—as this seems to be the easiest mode of looking at that "protoplasm" which we are told has *an identity of substance in all living being*,—what do we find but a collection of material suited for the building-up of the structure of the new creature. As we shall see presently, some electrical force soon begins the analysis, and carries the albumen to one pole, and the oily particles to another. Professor Huxley tells us that "a nucleated mass of protoplasm turns out to be what may be termed the *structural unit* of the human body."* But if a contractor were to cause to be brought together into one spot the whole of the material for building a house, would it be reasonable to call his thus furnished yard the *structural unit* of the future edifice? Further, would it be possible to imagine that the brick and mortar, the beams and tiles, had combined together to draw the plans, and by some molecular machinery of their own, found power to realize these plans?—"a great number of parts combining to perform each function, each part doing its alloted share of the work with great accuracy and efficiency, but being useless for any other purpose." †

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* *Lay Sermons, &c.*, 4th edit., p. 127.
† Ibid., p. 126.

9. "Protoplasm, simple or nucleated, is the formal basis of all life; it is the clay of the potter," says the Professor.* This may be very true, but we have been told before that it is virtually the clay and the potter too; and all this is attributed to *molecular* action.

10. Professor Huxley informs us† that the direction towards which modern physiology is tending, is towards the conception of *life* "as *the product of a certain disposition of material molecules;*" and he then seeks to show us how to escape, by taking refuge in the mysticism of Descartes, from the materialism towards which modern science thus conducts us. The simple reply to all which seems to me to be, that all we know of the action of *molecular* forces forbids such a supposition being entertained for a moment.

Fundamental Errors.

11. It is this fundamental error—the πρῶτον ψεῦδος, of this new school, that I here attack—the notion that molecules of matter may combine to act in a manner wholly foreign to the laws which govern them, and to produce results of organization which are wide as the poles asunder from all their powers. In order to effect this, *protoplasm* is made to do service in a way not anticipated by Mohl, who is *understood* to have first applied the term to the substance formerly termed by the Germans "*Schleim,*" a much more descriptive word, for supplanting which no scientific reason can be given; "*Urschleim*" again being far more characteristic for deep-sea protoplasm than the objectionable "*Bathybius*" of Huxley—*objectionable* as taking for granted what is not, and probably cannot be, proved as to its nature.‡

12. I must next remark that those (and they are many) who use the terms "molecular organization," "molecular forces," and "molecular machinery," imply that they are conversant with, and give in their adhesion to, the atomic theory; for it is only in connection with this theory that "molecules" have any definite meaning. At the same time, we may observe these very persons using the terms "molecule" and "atom" as synonymous; thus demonstrating either their entire ignorance of the subject, or their willingness to impose on those who incautiously afford them their credence, by a use of apparently learned words

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* *Lay Sermons*, p. 127. † Ibid., p. 142.

‡ See Dr. Lionel Beale's *Protoplasm*, pp. 20–21, for description of *Bathybius*. See also Appendix (C).

to veil absolute want of sense; than which nothing is more pretentious or more imposing; for, as Pope has well said,—

"*True no meaning* puzzles more than wit."

Of which maxim we may take the following sentence as an illustration:—"These phenomena are due to the properties of the *molecular machinery*, which has long been known to *exist in the imaginations* of highly-gifted persons; and although, as yet, no one has succeeded in actually producing such machinery artificially, the efforts of the philosophic imagination tend towards such a consummation."*

13. The strict construction of this sentence would, I suppose, require us to believe that the "molecular machinery" exists in the imaginations of certain persons, who are thereby enabled to become the prophets of the coming age. In what respect this qualification can differ from that which is called in Scotland "having a bee in one's bonnet," I am unable to judge.

14. The *Edinburgh Review* (April, 1873) † has well disposed of the claims and exposed the presumption of "the pseudo-scientific sect—the sect of the Darwinian evolutionists;" and the *Quarterly Review* (Oct., 1873) has given its powerful aid in combating the views of Herbert Spencer; my argument is, however, not superfluous (as I trust), but simple and definite, aiming to controvert the errors of the same school on one special but fundamental point; and I select from amongst the statements of the leaders the following sentence from the foeman whom I deem most worthy of my steel.

15. "The difference between a crystal of calc spar and amorphous carbonate of lime corresponds to the difference between living matter and the matter which results from its death. Just as by chemical analysis we learn the composition of calc spar, so by chemical analysis we ascertain the composition of living matter. It is not probable that there is any real difference in the nature of the *molecular forces* which compel the carbonate of lime to assume and retain the crystalline form, and those which cause the albuminoid matter to move and grow, select and form and maintain its particles in a state of incessant motion. The property of crystallizing is to crystallizable matter what the vital property is to albuminoid matter (*protoplasm*). The crystalline form corresponds to the organic form, and its internal structure to tissue structure. Crystalline force

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* *The Mystery of Life*, p. 68, quoting from Introductory Lecture on Life, &c., *British Medical Journal*, Oct. 22, 1870.

† Appendix (A).

being a property of matter, vital force is but a property of matter."*

16. This is all clear and definite. Nothing is wanting but accuracy in the foundation facts, and logical sequence for the superstructure.

17. To prove this, I must beg my audience to accompany me through a dissertation requiring some close attention.

Atoms.

18. In the first place, then, as to *atoms* and *molecules*. Ponderable matter is no doubt (*in thought*) infinitely divisible, but, in reality, this division has a limit beyond which the most powerful forces which we can bring to bear have no longer any effect. We therefore call these ultimate particles of matter *atoms*, from the Greek ἄτομος (from ἀ privative, and τέμνω, I cut), implying that which is incapable of any further division.

19. Notwithstanding their excessive minuteness, we have succeeded in assigning some of their properties, such as determining their relative weight. Of their form we are completely ignorant, but the probability is that they are spheroidal, and that each atom is a microcosm in the sense of having polarities and capacities of revolution on its axis, like the sphere of the earth.

20. A certain property of these *atoms* has received the name of *atomicity*,† indicating their capacity for combination. We know that 1 atom of chlorine combines with 1 atom of hydrogen, 1 atom of oxygen combines with 2 atoms of hydrogen, 1 atom of nitrogen combines with 3 atoms of hydrogen, 1 atom of carbon combines with 4 atoms of hydrogen.

21. These simple bodies differ among themselves by their capacity of combination with hydrogen, this being measured by the number of atoms of that element which they are capable of fixing.

22. A somewhat different property of atoms is their *affinity*; the cause, whatever it may be, of chemical combination. When a mixture of oxygen and hydrogen has been exploded to form water, we say that *affinity* has united the two primitive gases into a homogeneous liquid. The affinity is measured by the quantity of force (*vis viva*) which is transformed by the effect of combination, and which is manifested as heat. The energy with which a body combines with another body is looked upon

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* *Protoplasm*, p. 24.

† I am not answerable for this term, to which exception may be taken, neither do I pledge myself to the exact accuracy of the definition. It seems provisionally necessary.

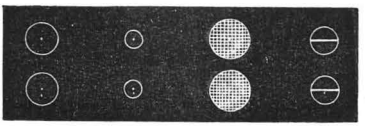
(rightly or wrongly) as independent of the faculty which it possesses of attracting one or more atoms of this last.

Molecules.

23. I have now to address myself to the attempted explanation of *molecules*, and I acknowledge to myself the difficulty, perhaps impossibility, of presenting to a non-chemical mind any exact idea of what is meant by this term. It has been well said that "in the least grain of dust, which appears to us inert, there exists an assemblage of vibrating atoms of magnificent arrangement, placed in lines, with a *fabulous precision* amongst themselves; and in such great numbers, that the most lively imagination is confounded."* Let me, then, clearly explain that a *molecule* is *an aggregation of chemical atoms.* We cannot call it a compound atom, for this would be a contradiction in terms, but the aggregation must be understood to act in certain senses as a unit.

24. In the gaseous state, the molecule of simple bodies is composed of many atoms of the same nature united together thus: the molecules of oxygen (*a*), of hydrogen (*b*), of chlorine (*c*), and of azote (*d*), are composed of two atoms turning one round the other, absolutely as the stars which form double stars are understood to do, and by constraint of the same laws.†

25. They may be represented thus:



a *b* *c* *d*

Their oscillation round each other may be figured thus:—

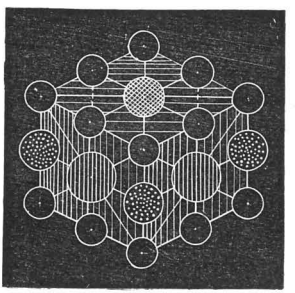
* *Monde des Atomes*, avant-propos, X.
† *Monde des Atomes*, p. 24.

26. As I give none of these statements on my own individual authority, I must refer my hearers to those works in which they are treated of, where they will find, if I mistake not, something like mathematical demonstration of the truth of the facts.

Crystallization.

27. When we leave the consideration of gaseous bodies and approach those in a fluid or in a solid state, we have occasion to believe that in the molecular constitution exists the reason for the difference between these states, and for the phenomena of transparency or opacity of bodies. It is not essential to my argument to pursue this theme; and it would not be possible in the present space of time to do justice to the subject: but I must endeavour to present the more complex idea of the molecule of mineral structure, especially as the mineral state is assimilated in the above passage to the state of death, and crystallized matter to the state of life.

28. I will, in the first place, bring under notice a traced copy of the form and arrangement of the molecule of a mineral (*Idocrase*), such as is inferred from the chemical analysis and from its mode of crystallization. I take this from a work published in 1873 by the eminent M. Gaudin, who is Calculator of the Bureau des Longitudes and Laureate of the Académie des Sciences at Paris. The molecule of this body is believed to represent a cube, of which three sides are seen in perspective in the accompanying projection. The lines along which the forces act are represented by dots, and the nature of the atoms is shown by the shading.



29. In this conception of the molecule, everything is understood to be arranged with mathematical certainty, and all ordered according to fixed and unalterable laws; so that, however numerous the molecules may be, each atom fills the like

place in each individual molecule, and all spin on their axes or vibrate according to arrangements which are as invariable as those which guide the earth in sweeping round the sun, and give us the seasons in their appointed course. No possible mutual agreement or spontaneous action can be supposed to take place among such bodies; and the idea of "molecular machinery" of any description displays as much ignorance, *chemically*, as, *astronomically*, the old conceit that the stars were really fixed, and moved in their orbits by a grand celestial orrery—"Cycle and epicycle, orb in orb."*

30. It must be fully understood that it is not in any way essential to my argument to show that the particular form assigned to the molecule of *idocrase*, or the exact constituent, must necessarily be correct in all points. It is simply a convenient illustration, and any other mineral might answer the purpose. I do not insist on those who are not equal to the task of grasping the mathematical and chemical proofs adopting the chemical theory of *molecules;* but I think all ought to insist on this—that the self-ordained instructors of the people should cease to use language such as "molecular machinery," which is either wonderfully ignorant or wilfully misleading.

31. I now come to the phenomena of crystallization, which are but a modified action of the same forces, working with the same mathematical regularity, with the same precision, adding molecule to molecule, in balanced, orderly arrangement. Often have I watched with interest the beautiful play of polarities which is manifested in crystals forming on the surface of a cooling solution ;† when the small needles seek or are repelled by their neighbours, according to the magnetic poles as they are developed; but I never should have dreamed of any person, however ignorant, making the above strange assertion, that a body in a crystallizing state, is to that in an amorphous state, as life is to death, or living matter to dead matter. Who is there that cannot see the difference between motion impelled by electrical current, and motion the result of voluntary choice and will!

32. "If we pour into a saturated solution of sulphate of potash a moderately concentrated solution of sulphate of alumina, and stir this mixture briskly with a glass rod, there follows immediately a disturbance in the liquid, and, at the end

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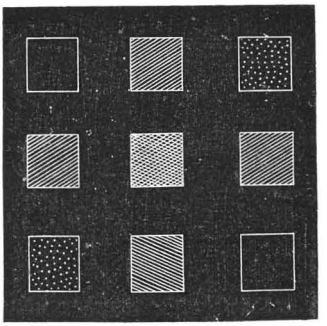
* See Milton, *Par. Lost*, book viii. l. 84. I can "correlate" the expression "*molecular machinery*," only with another term I meet with, "organized common sense."

† *Potassic chlorate* is a good substance to observe.

of some seconds,* crystals are precipitated of marvellous lucidity, sparkling like so many diamonds, which are, *without exception*, crystals of potassic alum in regular octohedrons; and if we suppose the diameter of these crystals equal to a millimètre, it will result from this experiment, that in the short space of a minute of time there have been produced molecules of alum composed, each one of 94 atoms, grouped amongst themselves with a perfect order, and that always the same;" the groups arranged in lines amongst themselves with an absolute precision, and in so great a number that I will not fatigue my readers with the recital of the attempted calculation, but refer to the original work, which I have pleasure in presenting to the Institute.

33. What then has the chemist done? Has he approached to the communication of life? Certainly not. He has simply brought the molecules of the different fluids into such juxtaposition that the play of affinities can take place; that atom can displace atom according to the inevitable laws of affinity and atomicity; or (as the Greeks said) of *Eros* and *Anteros*, of love and of hate. When the new combinations have taken place, the phenomenon of crystallization follows as a matter of course, simply because the molecules are different and differently arranged.

34. In order to place this part of my argument in as clear a light as possible, I will, in the first place, copy from the same author † a sketch of the probable manner in which molecules



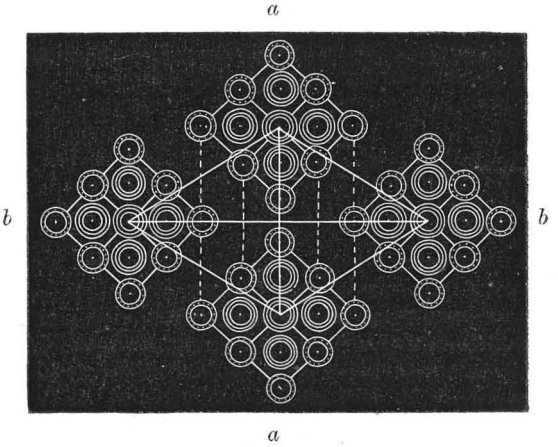
assemble side by side to form a *square* prism. It will be understood that the square figures represent not *atoms* but

* Many other instances might be adduced *more* striking in their instantaneous effect.

† *Monde des Atomes*, p. 65.

molecules of different substance, as indicated by the different markings. The crystal is commencing from the central cube; to which, according to probability, the others add themselves two by two or otherwise according to the laws of *crystallogenesis*, which we are beginning slowly to understand. The point essential to my argument is the simplicity of the process of crystallization, resembling the addition of brick to brick by the builder; the completed wall, however extensive, being the result of a thousandfold repetition of the same act.

35. The next figure that I shall place under the eye of the reader represents the probable formation of a rhomboidal crystal, commencing by the assemblage of two molecules (*a a*) oscillating



round their axis, till, the opposite poles approaching, they fix themselves in the position of greatest proximity indicated,—the other molecules (*b b*) adjoining themselves subsequently at a greater distance.

36. The rough copy I have made does not attempt to do justice to the beautiful drawing of the original; which indicates the horizontal plan of four molecules of *epidote*, and (by an arrangement of M. Gaudin's) denotes the constituent atoms; neither can I give the mathematical calculations, for all which I refer to the original work. The point which I insist upon is the simplicity of the nature of crystallization, and the apparent analogy of the forces which bind together atoms into molecules

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* *Monde des Atomes*, p. 66.

with those which arrange molecule with molecule into a crystalline arrangement. It is but to repeat this a millionfold, and a manifest crystal is formed.

37. Will it be *seriously* asserted that there is any comparison between crystalline and non-crystalline matter, and the contrast which, once established, can never be reversed, between living and dead matter. We cannot "revive" that which is, according to modern phraseology, "devived," though we can dissolve and recrystallize as often as we will.

Living Matter.

38. Dr. Beale informs us * that not even the smallest living particle seen under the 1-50th of an inch, or say less than the 100,000th part of an inch in diameter, consists of matter in the same state in every part; for it consists of, 1st, *living matter;* 2nd, matter formed from this; and 3rd, pabulum which is taken up by the living or germinal matter. The transition from one state into the other is sudden and abrupt, so that matter cannot be said to half live or half die. The germinal or living matter is always transparent, colourless, and as far as can be ascertained, perfectly structureless. This formless living matter moves forwards and burrows, as it were, into the nutrient pabulum, some of which it takes up as it moves on. It is not pushed from behind, but *it moves forward* of its own accord. This *spontaneous movement* is a characteristic of every kind of living matter. Living bodies exhibit the most active movements in various directions; a portion which is at one moment in the lowest point of the mass will pass in an instant to the highest part; one part will seem to pass through other parts, while the whole mass moves, now in one and now in another direction, and movements in different parts of the mass occur in directions different from that in which the whole is moving. Well may the intelligent observer remark, "What movements in lifeless matter can be compared to these?"

Life.

39. I shall preface my necessarily brief observations on this subject, by remarking that, as far as we know, *Life always proceeds from Life.* In the opinion of the ancients, animals crept forth ready formed from the earth (*primis prorepserunt animalia*

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* *Protoplasm*, pp. 33-37.

terris), and the mud of the Nile continued to produce monsters. Since that time the notion of spontaneous generation has receded gradually from view; having been driven from one hiding-place to another, by means of scientific and microscopical research; until in the present day it has been brought as nearly to the vanishing point as possible, through the labours of Pasteur and others. Those who still cling with pertinacity to this opinion will not deny that even if all they contend for (fruitlessly as I believe) were established as facts, these facts could not interfere with the general proposition above advanced.

40. In the next place it is obvious that since the commencement of the recorded history of animal life, as it has left its record in the ages of the past, *the mould* (or type) *in which creatures are formed has never been replaced.* Very many, certainly not less than 40,000, species of more or less noble and distinguished plants and animals have disappeared altogether from the earth, having been either exterminated by the hands of man, or having in other ways perished; whilst we cannot point to a single new species as having been introduced, either in the course of nature, or as created by the hands of man. "The *whole lapse of geological time has as yet yielded not a single new ordinal type of vegetable structure.*"*

41. This is strikingly contrasted with facts with which chemical science has made us familiar. Numberless new bodies have rewarded the pains of the experimentalist, who has been able, under the guidance of the atomic theory, to foresee the possibility of the existence of such and such a substance; and to take the needful steps so to alter or modify the atomic structure as to produce the result desired. In many cases we may assert that these products of human skill have never before existed; and yet they have their distinctive properties as fixed and unalterable as the law of gravitation itself.

42. For instance the chemist may take sulphur from the volcano, and oxygen from the air; he may separate iodine from the seaweed, and vegetable alkaloid, the product of processes of growth in certain plants growing at immense altitudes above the sea-level. He unites these for the first time; and produces new substances, having most definite forms of crystallization, by which the *Herapathite*,† as it has sometimes been called, of one alkaloid can be readily distinguished from another.

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* "Persistent Types of Life," Professor Huxley quoting Hooker's *Essay on Flora of Tasmania.* See *Lay Sermons*, p. 203 and p. 216.

† After my late lamented friend, Dr. Herapath.

These have again special relations to the rays of light; and disclose under the microscope objects of marvellous beauty to the human eye, which *never* can have beheld them till our generation.

43. I must claim, as one of the *pièces justificatives** of my argument, the admirable address by Dr. Russell to the Chemical Section of the British Association, Sept. 18th, 1873. The formation of Alizarine to take the place of madder, as there described, was strictly in accordance with the guidance of the atomic theory. An important manufacture has thus been established, and thousands of acres liberated for purposes more useful to man.

44. When the Biologists have done, I will not say as much, but when, in following out their theories, they have succeeded in creating one of the least of the creatures that plagued the Egyptians, I shall consider those theories worth examination.

45. Another point of very manifest and obvious contrast between crystallization and life is the *character of the unification.* In the crystal this is simply *aggregation,* the form being the result of forces which bind together molecule to molecule. Each part of a crystal might be removed, and the last portion would be as much crystal as the whole was as the beginning. As in the brick wall to which I have referred, brick by brick might be removed until only two bricks remained united together, but the character of their union would still be that of the entire structure.

46. But it is not so in an organized body. Here there is *union* of parts, all working together for the good of the whole. It may be compared with the oneness of an army, in which all the divisions are ordered by one ruling mind,—unseen it may be, but all-operative; and banding together all the soldiers into one harmonious *unity* of action. If in action one portion of the army is hardly pressed upon, orders are given by the commander for another corps to move to its support. So, it is most familiar to the cultivator of plants, that he has to do with an *organized structure;* and he takes his measures accordingly. So with the physician, who in the same manner calculates his resources for aiding the self-healing and self-sustaining power, the *vis medicatrix naturæ;* which is, after all, chiefly to be relied upon for the preservation of the creature.

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* Another of these will be found in the beautiful researches of Dr. Hoffmann, and specially in his recent formation of cumarine, "by displacement of atoms in the molecules."

47. The contrast between a living man and a statue is, then, very instructive as to the points we are considering. Both are continually losing particles of matter; but the living body is continually replacing these by an organization which keeps up from childhood to old age the identity of the body, repairing its losses, retaining the specific type throughout. Let us imagine our statue formed of protoplasm, and of this "formified," "vacuolated," "differentiated," "nucleated" to the utmost perfection, and, moreover, provided with all the "subtle influences" we can command, whether of electricity, magnetism, or any other force, and we should have a structure not only incapable of thought or action, but tending rapidly to dissolution; and with so much the greater rapidity, as the "forces" were accumulated within. "Something is wanting" of a totally different nature to the above forces, and this something is *life*.*

48. The notion of a crystal having any properties akin to those of a living structure appears to me to indicate entire ignorance of the first principles of crystallography, or even of chemistry.

49. A further contrast is shown by the absolute certainty and uniformity of action exhibited by the *chemical*, *mechanical*, and *correlative* forces. These, in their operation, are "fixed as fate," and the slightest deviation from their ordinary course would constitute a miracle.

50. On the other hand, nothing is more remarkable in the operations of *life* than the tendency to vary within certain limits; and also to incompleteness; or even (as it seems to us) error, in carrying out the purpose toward which the efforts of life are directed. Of the myriad buds of spring, how few are able to mature their fruit, even if they have succeeded in opening their blossom. In how few specimens of the human race are the right and left halves of the body equally well developed. How numerous, both in the vegetable and animal creation, are all kinds of what we call malformations, serving no very manifest purpose of utility; and leaving to the theologian a large province in which to exercise his skill; or perhaps, I should rather say, his faith.

51. Into this province I do not propose to enter; but to demonstrate the irreconcilable diversity between the operations of life and those of chemical or other force.

Analysis.

52. Having pointed out some of the more obvious contrasts

* λείπεται τι ἔνδον.

between crystallization and life, I now proceed to an examination in further detail of the assertion that "just as by chemical analysis we learn the composition of calc spar, so by chemical analysis we ascertain the composition of living matter." In the first place it is to be observed that all chemical analysis, even all ultimate analysis, is not equally satisfactory. If by *analysis* we learn the composition of a body, and by *synthesis* can again form that body out of its elements, then we have a result that commends itself to the mind. In other cases it is not so; and the professed ultimate analysis is not worth the paper on which it is written. Molière's woodman, having practical acquaintance with his work, exclaims, "*Il y a fagots et fagots;*" much more may those who apply themselves to the subject matter in hand, admit that chemical analysis is greatly at a loss to give anything like a satisfactory account of the composition of albumen, for instance; and, further, that it fails altogether in its account of the composition of living matter. There is analysis and analysis! If any one has watched, under a good microscope, the motion of the different currents in the *Chara* or *Vallisneria*, or still more the beautiful phenomena of the circulation of the blood, he will be little disposed to value the gross and imperfect results of the best analysis the chemist can give of these same circulating fluids; in which analysis many things must be confounded, and (as in protoplasm and *Bathybius*) misdescribed under one common name.*

53. I have myself found much silica, and that probably in a soluble state, in an analysis of the cambium† (which is the *protoplasm*) of an English tree, but I know not how to separate the formed from the unformed portion, and can therefore not certainly say to which of the two it belongs. I can only suppose that it was a very likely material for building the excessively delicate cell-structure.

54. I refer to M. Trécul,‡ for a beautiful illustration of renewed growth upon a decorticated stem of *Nyssa Angulisans*, showing how the renewed bark arises from the cambium.

55. Even the Abyssinian, who cut from the living animal his steak of *protoplasm*, knew how different its properties were from the same steak when cooked; and the philosopher, when supplied with eggs unboiled for breakfast, would not find his equanimity increased by the information that the difference between boiled and unboiled was in no way *material*, because it could not be detected by analysis.

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* See Appendix (B). † See Appendix (C).

‡ *Annales des Sciences Nat. Bot.*, t. xvii. pl. 17.

56. In fact, we must needs complete that which our appliances leave so defective, by mental analysis; and, without *proof*, but with probability, decide that even in the simple processes described, we have altered the composition of every molecule of matter in (for example) the oleaginous matter and the albumen of the egg.

57. When we take albumen, subject it to heat and distil off the water, we have no longer in reality *albumen* plus *water*. That which is left is a horny substance, incapable by all our art of so taking up again the water into its composition as to become what it was before.

58. I deny, then, tbat ultimate analysis can give us in all cases satisfactory information as to the character even of non-living bodies.

59. The denial becomes much stronger when applied to living bodies. To prove this in detail would demand a treatise; but I think it may be made sufficiently apparent by a few considerations.

60. All living beings are composed essentially* of four chemical elements, carbon, hydrogen, oxygen, and nitrogen, which are combined in various proportions.

61. But chemical affinity and vital affinity are *opposed* the one to the other, and on this point of such fundamental importance chemistry fails to afford us the requisite information; for it does not dispel the darkness that is around us. To formularize the matter thus: Let C be Carbon, H Hydrogen, O Oxygen, N Nitrogen, ♀ Life; † then

C. H. O. N. + ♀ = organized beings
C. H. O. N. − ♀ = products of decomposition.

62. What then is this "Life" on which so much depends, and concerning which ultimate analysis gives us no information?

63. If we look at the difference between the impregnated and the non-impregnated egg, we find that ultimate analysis fails to discern the slightest difference; yet in the latter case we have animal substances, destitute of the principle of life, hastening to resolve themselves into the products of decomposition. In the former we have *in posse* all the wonderful organization of the fowl attached to the as yet apparently unchanged matter of the egg.

64. Then when we allow our minds to grasp the vast and almost illimitable variety of creatures which spring from an

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* Neglecting accessory ingredients. † The Egyptian symbol of life.

egg,—and consider that all these to the chemist, are, so to speak, alike,—we learn how very limited, after all, his powers of analysis are.

The Cell.

65. A great deal has been said and written connecting the *cell*, in some mysterious manner, with the beginnings of life. The *cell-wall*, however, is that which constitutes the *cell;* and this no more represents to us that which is going on inside, than the walls of a council-chamber (*Cella*) could report to us the important deliberations carried on within. We want, in either case, to understand that which is at work in the interior; the destinies of nations depending on the latter; in the former the formative idea working from the unseen to the seen, and sketching out the outlines of the creature that is to be produced, to be afterwards elaborated in detail after its kind.

The Egg.

66. According to Balbiani (as quoted in a work from which I extract the following details), the egg of some creatures (*Spirostomum, Stentor*) is a *mere cell*, without any other sign of the characteristic nucleus-like vesicle, the so-called *germinal vesicle*, than a clear spot in the midst of the yolk granules. In some cases, as in the *Amœba*, the parent of the egg is as simple in structure as the egg itself; and yet this most simply organized creature possesses *will* to determine its actions, and some sort of *sense* to guide its pursuit of food, as well as *power* to seize its prey and to assimilate this when apprehended; so that connected with that simple cell which forms its egg may be wonders past our finding out.

67. Even Dr. Huxley seems to give up the old notions of cell-formation, and in a beautiful description which I shall immediately give, shows that the *commencement* of formation may be in a "*structureless*" sac.* Dr. Lionel Beale assures us that germinal matter is not unfrequently entirely destitute of *nuclei*,† but these bodies sometimes make their appearance if the mass be more freely supplied with nutrient matter. So far from nuclei being formed first and the other elements of the cell deposited around them, they make their appearance in the substance of a *pre-existing* mass of germinal matter, and become new centres of formation.

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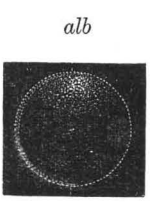
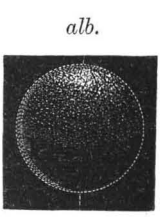
* Appendix (D). † *Protoplasm*, p. 45.

68. In the same manner, as it seems to me, spiral and reticulate vessels arise in the lax tissue of vegetable growth and become the determinative and formative element of new structure, as we shall see further on.

69. I copy the following admirable description from Professor Huxley * (not being myself an anatomist) :—"Examine the recently-laid egg of some common animal, such as a salamander or a newt. It is a minute spheroid, in which the best microscope will reveal nothing but a structureless sac, enclosing a glairy fluid holding granules in suspension. But strange possibilities *lie dormant in that semifluid globule.* Let a moderate supply of warmth reach its watery cradle, and the plastic matter undergoes changes so rapid and yet so steady and *purposelike* in their succession, that one can only compare them to those operated by *a skilful modeller* upon a formless lump of clay. *As with an invisible trowel,* the mass is divided and subdivided into smaller and smaller portions, until it is reduced to an aggregation of granules not too large to build withal the finest fabrics of the nascent organism. And, then, it is *as if a delicate finger* traced out the line to be occupied by the spinal column, and moulded the contour of the body; pinching up the head at one end, and the tail at the other, and *fashioning flank and limb* into due salamandrine proportions, in *so artistic a way,* that after watching the process hour by hour, one is almost involuntarily possessed by the notion, that some more subtle aid to vision would show the hidden artist, with his plan before him, striving with skilful manipulation to complete his work."

70. The following sketches, copied from *Mind in Nature,* † will illustrate the gradual accumulation of the albuminous particles round what must be an electric pole, whilst at the opposite pole the oleaginous matter assumes a peculiar kind of refraction.



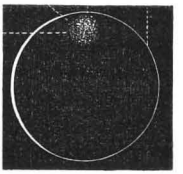


* Huxley's *Origin of Species.*

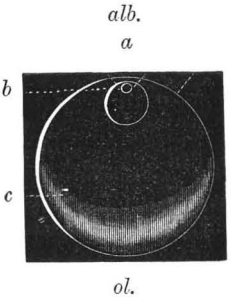
† *Mind in Nature; or, the Origin of Life, and the Mode of Development of Animals.* By Henry James Clark, A.B., B.S, &c. &c. New York, 1856.

71. The egg in its inception is a minute aggregation of *fluid* matter; but this drop of fluid has not a homogeneous, uniform density throughout, but makes its first appearance in the form of an *indefinitely bounded* globule with a greater degree of transparency on one side than the other.

72. Soon, and whilst the egg is yet minute, the albumen becomes concentrated and assumes a somewhat globular outline. At the same time a condensation takes place at one side.



73. The aim of all these processes becomes now rapidly apparent, for soon we find that the albumen has clearly become



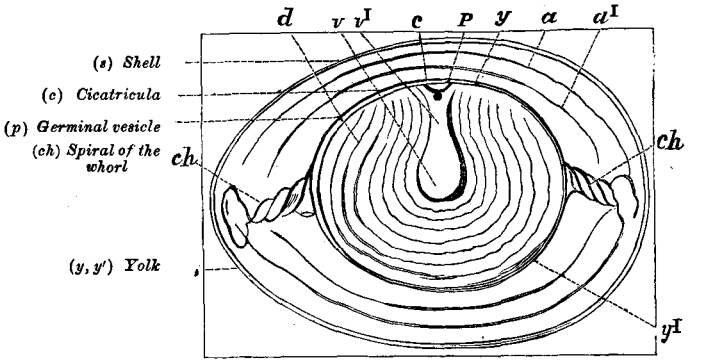
a, Germinal duct.
b, Germinal vesicle.
c, Yolk.

defined as a separate mass, apart from the yolk, and its superficies has become condensed into a well-marked envelope, which constitutes the *germinal vesicle;* whilst the condensation going on within it at the last stage has resulted in the formation of a clearly-established agglomeration, with a distinct wall around it, called the *germinal spot.* Outside this field of operations, and antagonistic to it in character, the yoke has its peculiarities, its physiognomy, refraction, density, opacity, and colour, according to the kind of animal into which the egg develops, all tending to demonstrate that it is under a *different* formative influence

from that of the albumen, or, as we may say, at an opposite pole.

74. We may therefore define an egg, so far as chemistry can inform us, as a globular accretion of two kinds of fluids, *albumen* and *oil,* which are situated at opposite sides or poles.

75. I now present from the same source the perfect egg of a hen, (which has been boiled,) in section,—in which sketch will be distinguished the shell, the spirally-wound layers of the white (albumen) twisted into chords, which serve as axles, upon which



the yolk swings and revolves whenever the egg is rolled over, so as to keep the side with the white spot (*cicatricula*) uppermost, and nearest to the warmth of the hen.

76. It is impossible, even with prolonged boiling, to harden that part of the yolk (v, v') which extends from the white spot to the centre.

77. From Wagner's *Elements of Physiology* I take what seems to be in some respects a still better representation.*

78. I think it unadvisable to do more than indicate from Wagner the *commencement* of the development of the perfect animal. Every one can folllow up in thought the formation of the members of the perfect animal, "which in continuance were fashioned when as yet there was none of them."

79. Here, in the *nota primitiva,* or primary streak (a), is the first indication of the new being after twelve to fourteen hours' incubation. Another, from Cuvier's *Règne Animal,* shows the

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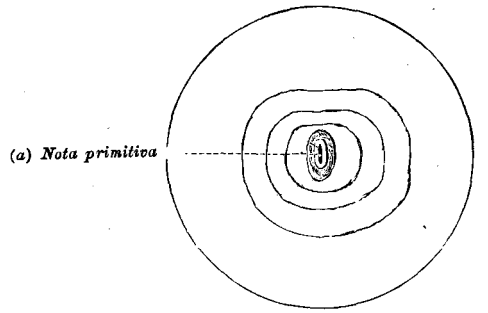
* This is omitted in printing the paper. The reader is referred to the original.

rudiments of the cerebro-spinal axis and of the vertebral column after thirty-six hours' incubation.



80. The outer circle represents the boundary of the yolk; but I must fix attention on the central streak, which is destined to become the foundation of the living structure. All that we have been considering simply subserves the development of *this little streak*, and all is swallowed up in the course of its extension into the perfect chicken, and, as every one knows, nothing but the broken shell remains when *that* has emerged. All the rest has been simply predestined to subserve this purpose.

Contrast.

81. Now I would ask what resemblance can the most exalted scientific imagination detect between this and the aggregation of atom to atom, and of molecule to molecule, in crystallization?

Development.

82. It would prolong to an unreasonable length, though it might strengthen the argument of this paper, to consider the further development of living creatures from the embryo; but I hope I have made it quite evident that, in place of chemical affinities binding atom to atom and molecule to molecule, acting with mathematical precision, at inconceivably small distances and on particles of matter inconceivably minute, we have, before we can account for the phenomena of life, to find out the *formative power;* * which, working from the invisible, and being itself imponderable, can guide, control, coerce, or, if

* "En résumé, il existe dans tout le règne organique une *puissance formative*, qui, dans le règne végétal, agit principalement d'une manière symétrique, puis, en outre *conformément à un certain but.*"—Link, Recherches

needful, hold in abeyance for a season all the ordinary forces with which we are acquainted. Wherever there is an *organism* there must be an *organizer*, and *this* working apparently according to a predestined design, capable of carrying out this design within certain limits of oscillation, able to sustain the structure to which it is attached or with which it is united, and to repair damages to a certain extent, varying according to the complexity of the structure; so that the starfish that has lost a ray does not produce a crab's claw in its place; nor does the lobster, in place of its lost claw, by any chance assume a human hand. In the very least organized creature—and they have been *measured* not larger than the thousandth part of a millimètre (·003937th of an inch)—the special organizer must have under its absolute control as many atoms of matter, it may be, as London contains of inhabitants; yet, while it holds sway, not one of these starts on an independent line. As soon as the creature *dies*, all this is reversed, and the chemical affinities resume their sway. The organizer is capable of assuming suitable matter to complete its organism, and this to any extent required, and also to provide for the continuance of this assimilation; so that every creature that we know of tends to an excessive reproduction; and the world would become too full if it were not that each creature (as it seems) has its special destroyer or destroyers. It is admirable with what *apparent* foresight and forecast this principle which we vaguely call *nature* works within ourselves, all unconsciously to ourselves; for if a bone is broken (for instance), the processes that are immediately set up to repair the mischief would certainly not be improved upon by consultation of the whole College of Surgeons. Yet what is it that practically adapts all this provident knowledge to our healing? Is it some "molecular machinery in our imaginations," or, as explained according to a *great* authority, "the poles of the atoms are arranged that tendency is given to their powers, so that, when the *poles and powers have free action* and *proper stimulus* in a suitable environment, they (the powers? or the poles?) determine first the germ and afterwards the complete organism?"*

83. How much we are indebted to "*the powers*" and "*the poles*"!

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sur l'Accroissement végétal et la Greffe, *Ann. des Sciences Nat. Bot.*, t. xiv. p. 30.

"Les jeunes tissus végétaux, ceux de la couche génératrice en particulier, ont la propriété de se modifier, de se metamorphoser, pour produire tel ou tel organe dans telle ou telle situation, *suivant les besoins de la plante*."—Trécul, *Ann. des Sciences Naturelles*, t. xvii. p. 276.

* Dr. Tyndall, quoted in *Life Theories*, p. 27.

84. I have shown in *The Quinology of the East Indian Plantations* the elaborate manner in which the bark is renewed by the cinchona plant, after having been removed for the purpose

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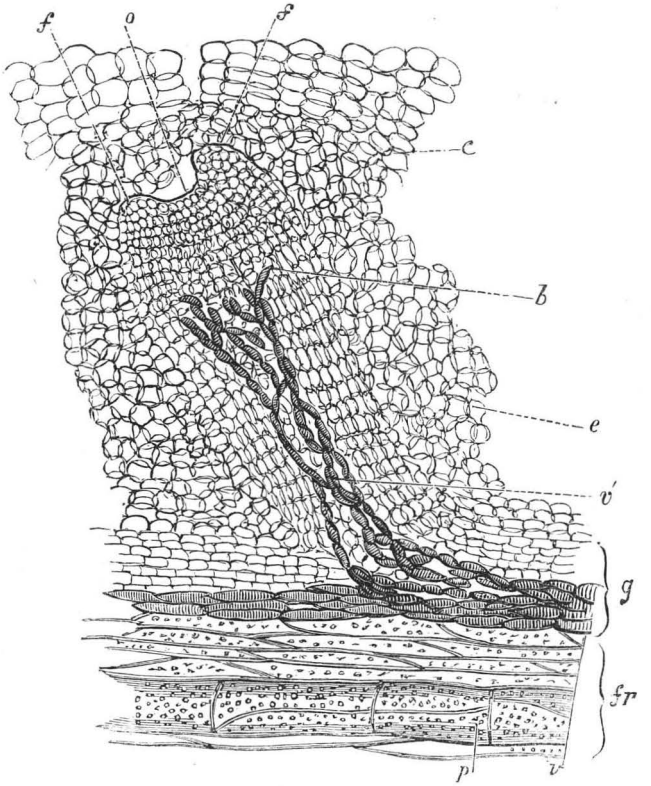
LONGITUDINAL SECTION of a fragment of a sucker of *Paulownia imperialis*, showing the structure of a *very young bud: fr*, a small portion of the fibro-vascular system of the root which produced the sucker; *p*, a punctuated vessel of this part; *g*, the generative layer; *c*, external cortical tissue; *e*, cellular protuberance, which proceeds from the internal cortical tissue, raises the external cortical tissue *c*, and in which is seen a very young bud *b*: the base of this bud is inserted in the generative layer *g* of the sucker; this bud is terminated by little projections *f*, which represent the first nascent leaves; vessels *v'* contiguous to those of the generative layer *v*, pass along its whole length, they are in relation with the lower part of the sucker.—(From the *Annales des Sciences Botaniques*, t. vii., viii. (1847), p. 291.)



Cortical tissue. Rudiments of the first leaves. Internal cortical tissue. Cells very small and faintly traced. Young bud forming. Extremity of the vessels. Couche génératrice. Fibro-vascular system.

of commerce. No female hand, in copying the most beautiful design of lace-work, could produce more exquisite elegance of structure than is apparent under the microscope, arising from

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Section of the stem of an elm,* from which plates of bark have been raised all round the tree, some from above downwards as at *a*, others in the contrary direction as at *b*. These strips of bark have remained adhering by one of their extremities either to the bark above *E*, or to the lower bark *E'*. At *g* the strips of bark have been removed in order to show better what has taken place during the experiment. From the upper surface of the wound have arisen numerous adventitious roots *r*. The strips of bark *a* and *b* have given rise to plates of bark, which attain one centimètre in thickness. They are clothed with new bark ; the surface of the denuded wood has also produced thick layers of wood and of bark *c*. At the surface of the new productions *l*, plates of bark or of denuded wood have arisen from tubercles bearing each seven or eight adventitious buds.

r r, Adventitious roots thrown out as the result of decortication of an elm.

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* Trécul, *Annales des Sciences Naturelles Bot.*, t. xx. pl. 8.

that which at first seems but an exudation from the heart-wood of the tree—the only indispensable requisite being that the cambium* or *living part,* should not have been removed, and that the surface should be protected from undue evaporation. We see how wonderfully nature "formifies" the part, adding by degrees that which is necessary, as the spiculæ or fibres; and "vacuolating" or forming channels for the conduct of the milk-sap of the plant. The spiral and reticular vessels are the first indication of the *intention* (so to speak) of the plant to throw out either branches or roots,† to find some means of replacing its loss; and the crystals, which are in no way the result of vegetation, but form after the bark is stripped from the tree, show the mathematically correct structure I have dwelt upon; so different from the free and varied forms resulting from life.‡

Organism.

85. In describing this, in the work cited, I have said "that I place no faith in any of the theories of vegetation which *isolate* the different parts of the plants; but I agree with Kant, in what seems to me a clear definition, that "the cause of the particular mode of existence of a living body resides in the whole," and with Müller, from whose *Physiology* I quote, that "there is in living or organic matter a *principle constantly in action,* the operations of which are in *accordance with a rational plan,* so that the individual parts which it creates in the body are *adapted to the design of the whole,* and *this it is which distinguishes organism.*"

86. It is certainly to be desired that the words *organic* and *organize* should be carefully applied. It is difficult to understand in what sense they are used by some "thinkers" of the present era.

87. Hutton, in his day, suggested that the earth might be "considered as an organized body" "having a constitution in which the necessary decay of the machine is *naturally repaired,* in *the exertion of those productive powers by which it had been formed.*" This exercise of the philosophical imagination was scarcely appreciated by his contemporaries; perhaps it is reserved for our descendants to look upon the earth as *really* a living creature.

88. But what am I to make of the expression "*organic*

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* Compare with the plates in the above volume, the cambium in Dr. Beale's *Life Theories,* plate II. fig. 1, the layer (c) "*containing bone-forming proplasts,* for an interesting analogy between vegetable and animal formation.

† Compare the diagrams in the preceding pages 197 and 198.

‡ See the work referred to, now in the Library of the Institute.

crystal" used in the following sentence? "Suppose that we had known nothing of the lobster but as an inert mass, an *organic crystal,* if I may use the expression."* It seems to me that the supposition could never be made by one who really understood chemistry, or could comprehend the difference between crystallization and life.

Conclusion.

89. In concluding this paper, I must say that I am deeply impressed with the importance of recognizing the truth that life is a gift of the Almighty, to be regarded therefore as sacred to the Creator and Preserver, and neither to be communicated nor taken away but according to his laws.

90. There is an irreconcilable opposition, a total contrariety between this doctrine, which lies at the foundation of all civil society, and the religion of M. Comte,† which would wholly subvert the existing order of things. The adherents of Positivism and the disciples of Darwin are sufficiently outspoken on these subjects. It would be most unjust to Professor Huxley to represent him as advocating the errors of M. Comte, against which he has written with his usual force of argument. In one respect he seems to acknowledge the influence of his writings, in his sympathy with those who have been impelled by him to "think deeply upon social problems and to *strive nobly for social regeneration."*‡ It is just here that the danger lies; for the more people are impelled to regenerate society, without having anything definite in their own creed, the more mischief will ensue from their endeavours. Professor Huxley describes himself as "one whose boat has broken away from the old moorings," and who had been content "to lay out an anchor by the stern until daylight should break and the fog clear." He seems by his quotation-marks to allude to the shipwreck at Melita; and if so, would do well to remember that on that occasion it was in consequence of *listening to an apostle* that they all escaped safe to land. Would that a like regard to authorized *testimony,* and a like happy result, might in his case be the termination of a state which must be trying to the patience even of a philosopher. One thing is clear, that it is a position which the multitude of mankind would never consent to occupy.

91. I hope that the study of these subjects will result in increasing perception of the above; and of the impossibility of compromise between truth and error on such fundamental

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* *Lay Sermons,* p. 106. † See Appendix (D).
‡ *Lay Sermons, &c.,* p. 173.

points. It is a subject of congratulation and thankfulness that so many of the clergy have arrayed themselves under the banners of THE VICTORIA INSTITUTE ;—thus to promote that which has been said to be a peculiar advantage possessed alone by the Roman Catholic clergy, that "the *heresies of the day are explained to them by their professors of philosophy and science, and they are taught how these heresies are to be met.*"*

92. Professor Huxley desires to supplement the deficient instruction of the people by "Sunday evening addresses upon non-theological subjects;" and would "like to see a scientific Sunday school in every parish, not for the purpose of superseding any existing means of teaching the people the *things that are good for them,* but side by side with them."

93. I do not at all intimate that Dr. Huxley would wish the people instructed either in Comtism or in Communism; but as the Professor holds a distinguished post in "the Royal Commission on Scientific Instruction and the Advancement of Science," and as the above idea of *scientific instruction for the masses* has taken deep hold in many quarters, I insist on the necessity that exists for first of all distinguishing between true and false science, and of exploding the *false* whilst we adhere to the *true.*

94. Let any person of common sense decide, what would be the effect of teaching children, *side by side,* the origin of life as stated in the Book of Genesis; and the notions of some men of science which we have been considering in this Paper.

APPENDICES.

(A.)

(From the *Edinburgh Review,* April, 1873, p. 5.)

"The practical influence of the new doctrine is seen in the rise and rapid growth of a pseudo-scientific sect—the sect of the Darwinian evolutionists. This sect is largely recruited from the crowd of facile minds ever ready to follow the newest fashion in art or science, in social or religious life, as accidents of association or influence may determine. . . . .

"The evidence in favour of the central Darwinian doctrine is notoriously deficient, but this is no hindrance to its enthusiastic acceptance. Ardent

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* Prof. Huxley's Essay on *Scientific Education,* p. 62.

neophytes easily personify the principle of evolution, and clothe it in imagination with all the powers necessary for the production of its reputed effects. . . . . On all doubtful points their subjective conviction is so strong as to be independent of objective verification or outward proof of any kind. . . . .

"The cavils of sceptics are of no avail with the true evolutionist believer, because he has an unfaltering trust in his own sacred books and inspired writers. At their bidding he is ready to adopt not only things unsupported by reason, things above and beyond reason, but things directly opposed to all reason, all probability, and all experience.

"Another note of sectarianism in the evolutionists is their tendency to intolerance. The tendency is manifested, perhaps, in its extremest form amongst the rank and file of the sect. It displays itself, however, in various shapes, some of which are amusing enough.

"This tendency to intolerance appears also in the writings of the school, especially in the less distinguished. The tone of the discussion in many cases involves the tacit assumption that the evolutionists are the only wise men, and wisdom itself will die with them. This feature comes strongly out in the journals of the school in the free use of such terms as 'exploded' and 'extinct,' applied to all opposing theories and rival views."

(From the *Quarterly Review*, October, 1873, Art. *Herbert Spencer*, p. 537.)

"A passionate hatred of religion, however discreetly or astutely veiled, lies at the bottom of much of the popular metaphysical teaching now in vogue. *Delenda est Carthago!* No system is to be tolerated which will lead men to accept a personal God, moral responsibility, and a future state of rewards and punishments. Let these unwelcome truths be once eliminated, and no system is deemed undeserving of a candid, if not a sympathetic consideration; and *cæteris paribus*, that system which excludes them the most efficaciously becomes the most acceptable."

(B.)

"Qu'est ce que le Cambium? Grew, qui en a emprunté le nom et le sens aux médecins de son temps, n'y voyait q'une *humeur*. Duhamel y voit de plus une couche, et, d'après lui, les Allemands une couche de formation (*Bildungs-schicht*), d'accroisement, d'épaississement; Mirbel une couche génératrice ou régénératrice. Tout cela peut être vrai à la fois; si le cambium n'est pas un tissu, c'est l'origine d'un tissu, la matière d'un tissu ou des tissus. Comme cette matière enferme incontestablement de la sève, je l'appellerai *matière séveuse*, pour n'affirmer rien que ce que nous en voyons." —Guillard, "Sur les Mouvements et les Lieux spéciaux de la Sève."

Bul. de la Soc. Botanique de France, 1867, p. 67.

(C.)

(From *The Depths of the Sea*, by C. W. Thomson, LL.D., &c., Regius Professor of Natural History in the University of Edinburgh, &c.)

"I feel by no means satisfied that *bathybius* is the permanent form of any distinct living being. It has seemed to me that different samples have been different in appearance and consistence; and although there is nothing at all improbable in the abundance of a very simple shell-less '*moner*' at the bottom of the sea, I think it not impossible that a great deal of the '*bathybius*'—that is to say, the formless protoplasm which we find at great depths—may be a kind of *mycelium*, a formless condition connected either with the growth or with the decay of *many different things*." (p. 415.)

"The German naturalists of the new school, in their enthusiastic adoption of the Darwinian theory of evolution, naturally welcome in these '*moners*' the essential attribute of the Urschleim—*an infinite capacity for improvement in every conceivable direction*." (p. 409.)

How is it, then, that they are contented to remain *moners* still?

(D.)

The same apparently "structureless" character distinguishes the bud.

"Le bourgeon, soit libre (embryon), soit fixe, n'est d'abord qu'une petite masse homogène, un globule de matière séveuse, où n'existe formellement aucun des organes qui un jour auront leurs fonctions spéciales dans la plante. Sur le pourtour de ce globule, émergent bientôt les feuilles, d'abord dans la même simplicité d'organisation. Puis à mesure que ces feuilles rudimentaires grandissent, un courant séveux se détermine, se dessine dans chacune d'elles; et après lui, des courans latéraux, qui aboutissent à ce courant dorsal; celui-ci se prolonge lui-même dans le globule qui est la base commune de ces rudiments de feuilles."—*Bul. de la Soc. Botanique de France*, 1867, p. 70.

(E.)

(From the *Gazette des Tribunaux* for March 2, 1870.)

The affairs of M. Comte came into the French law courts after his death. I extract the following particulars, evidently authentic, from the speech of M. Griolet, *avocat* of Madame Comte:—

"M. Auguste Comte, who is now celebrated as the founder of a new system of philosophy, the *positive* philosophy, died at Paris, in the month of September, 1857. . . . . M. Comte has himself divided his life into two epochs, and his work into two parts. During the first of these eras he filled, with distinction, different posts in the *École Polytechnique*; he created and

developed a new system of philosophy. In the second he lived, having separated from his wife, 'en communion objective et puis subjective' (to employ his own expressions) with a young woman, Madame Clotilde de Vaulx; he created a new religion, the religion of humanity; he constituted himself the chief priest of this doctrine, which he expected *shortly* to govern the religious, political, and social destinies of the world." *

He also made the will which was called in question by his wife, on the ground of alleged insanity, in the which he outrages his wife,† and makes singular disposition of his effects.

His taking up with the wife of a banished convict (after he had separated from his own) is thus described:—"It was at this time that he met a young woman, who had come to Paris to publish some literary essays. She (Madame de Vaulx) was married, but her husband was separated from her by a sentence ‡ of an afflictive and dishonouring character. M. Comte, who was then 47 years old, conceived for this woman the strangest passion. They became together godfather and godmother of a child, and M. Comte thought that their union had been consecrated by this ceremony. Madame Clotilde de Vaulx became seriously ill and died. But to these relations, of which M. Comte always attested the purity, he added a subjective union which never ceased. It is Clotilde de Vaulx who, from that time, *inspires all his thoughts*, dictates all his works, directs all his acts. She is his eternal companion, his guardian angel, his *goddess*. She is even to become the *goddess of humanity*. Her worship will be united to the worship of humanity itself. '*Her image*' he says, '*is destined to furnish to regenerate souls, the best emblem of the Eternal Being*'"! §

Such is the character of the inspiration before which that of prophets and apostles is to fade away. Such the character of the teacher of the new philosophy, who has had *some* success amongst his own countrymen, but "*in England* the success of M. Comte has been *greater*. He has, perhaps, fewer disciples, *but his ideas have penetrated more into English philosophy*, and the translation of his works has taken its place *in ordinary teaching*."

The "eternal companion" of the philosopher treated the poor despised wife with the jealousy of a "goddess" of the old mythology. She could not suffer the rivalry (*concours*) of the legitimate wife. This last was then banished and forsworn. She becomes in all his works, "l'indigne épouse," although, to her careful nursing he had, at an earlier period, owed his life and reason. It is well to look these things in the face before we intrust to *our* philosophers the place they contend for as teachers of the rising generation.

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* *At present* it would be impossible to present to an English reader the speculations suggested in the above. See tome iv. pp. 33, 320, *Système de Politique Positive*.

† "Outragée dans la manière la plus grave."

‡ "Une condamnation afflictive et infamante."

§ "Le meilleur emblème du Grand Etre."

The CHAIRMAN.—I am sure we must all with acclamation return our thanks to Mr. Howard for his very able and excellent paper. In commencing the discussion, it may perhaps be agreeable to you that I should point out one or two of the palpable fallacies which have been put forward in support of the doctrine so admirably controverted in this paper—namely, that there is a strict analogy between the inorganic processes, such as the formation of a crystal, and the organic processes, such as the formation of a living being. On one occasion, at a meeting of the British Association, I remember a lecture was addressed to the working men of Dundee, and I could not help thinking what a pity it was that so false an analogy should be specially addressed to the working men of one of the great centres of Scotch industry, who were so little capable of recognizing the very limited extent of the analogy placed before them. Professor Tyndall, who gave the lecture, called attention to the resemblance to the formation of what we may call fern-like leaves, by what is commonly known as the production of the zinc-tree or the lead-tree. If you place a solution of sugar of lead in a bottle and hang a little ball of zinc at the top of the bottle, and wait a certain time, beautiful leaf-like formations will take place, which in fact result from the acetic acid of the sugar of lead taking up the zinc and setting free the lead. The lead forms thin laminated crystals, which are thrown out, and are very fern-like in appearance. The argument of the lecturer was that just as this action produces fern-like branches, so the real ferns are produced by analogous means. But there is a fundamental error underlying this proposition. It is simply this: that under whatever circumstances and from whatever source you derive it, exactly the same form takes place in the crystallization of lead, or the crystallization of silver, or of any other substance. If you re-dissolve it exactly the same thing may again take place, whereas in the formation of plants we know that the same elements of carbon, hydrogen, oxygen, and more or less of nitrogen, with portions of lime and silica, meet as air, water, and earth, and form these plants, but do they always form the same? No, certainly not. The individual plant formed depends on the influence of the pre-existing germ derived from another organism of the same kind, which determines the particular mode of combination of the inorganic element, so as to form an individual similar to that from which the germ was derived: *there* is the essential difference. You have the same elements producing every variety of plant from the soil and the air according to the influence of the seed—that is, of a germ derived from a similar organism, whereas in the simple inorganic formation of a crystal you have exactly the same crystal formed from whatever source you derive the crystallizing element. Another error of the same kind, and what was more subtle, was put forward in a work by Professor Tyndall, called "Fragments of Science for Unscientific People," in which he refers to polarized light. It is well known that if you take a section of crystallized carbonate of lime in a direction perpendicular to the axis of the crystal, and expose it to the action of a polarized ray, you have a series of rings with a black cross. If you take certain organic elements, such as particles of arrow-root or starch-grains, and examine them under polarized

light, you will see a black cross produced in the granules—produced in the passage of this light through these granules. The Professor then goes on to say that just as the black cross results from the crystallization of the calcite, so the black cross results from the organic formation to which he alludes. But the two things are totally different, which he ought very well to know, and rest on totally different grounds. The effects manifested by the passage of polarized light through a crystal are invariably the same from whatever source the crystal is derived, and if you have a mass, and take the smallest portion of any part of that mass, you will find that exactly the same effects are produced by the transmission of polarized light. The molecules of which it is composed are arranged in a certain definite order in the way in which Mr. Howard has happily shown in the early part of his paper, whereas in starch-grains the case is totally different. The action of polarized light on starch-grains results entirely from their being in a state of strain, and any inorganic substance which is in a condition of strain will exhibit certain effects in a polarized ray. Now any organic substance, such as horn, or a great many other substances when perfectly dry, desiccated as starch granules are, and which in the process of desiccation have undergone a certain amount of molecular strain, show under that condition of strain a peculiar action on polarized light. Just the same thing takes place with a piece of unannealed glass. Unannealed glass is very readily broken by the action of heat, or any mechanical disturbance of its molecules. Take, for instance, Rupert's drops, small pieces of glass suddenly cooled by being dropped into water. The exterior is more rapidly cooled than the interior, and a contraction is produced which occasions a strain on the interior molecules. So if you take a piece of unannealed glass you will find, on submitting it to the action of a polarized ray, that you will have a black cross. But it is far from corresponding with the crystal, whereas if the piece of glass were a crystal of calcite, every part of it would present exactly the same character under the action of polarized light. But whereas in a piece of unannealed glass it results from a strain, if you cut off the sides of a circle and reduce them to a square you will have very different figures produced. So if you take a circle and scallop its circumference, you will then have a totally different figure produced, because in that case you have removed the external strain in rather a different manner. I think this is quite sufficient to explain to you that the analogy is a totally false one, and that it is not true that just as the black cross is in the one case so it is in the other, but that there are two somewhat similar results produced by totally different causes. I have brought this forward as one of the specious arguments which some men of science will put forward, I might almost say, in order to mislead the unwary. I hope that some of our friends will make some observations upon Mr. Howard's paper. It appears to me to be most important that the clearest and most intelligible conception should be given to the unscientific, as to the fundamental distinction that exists between the results of any mere molecular action, and organization which is the result of vitality. And it must always be borne in mind that whereas in the case of inorganic formation the

precisely same results follow from whatever source you derive the material; in results determined by the existence of some germ or seed derived from a previously organized individual, and which determines the formation of a similar organism, there is an essential difference which is invariably found to exist between organic and inorganic force.

Mr. David Howard, F.C.S.—There is one point I wish to call attention to, which I think may somewhat assist the very clear exposition we have in this paper; that is, the curious way in which crystallization seems to touch life—always from below. In very many cases life produces crystallized bodies, but I think one may safely say it is merely the result of destruction, the result of waste, or of secretion; it is after life that crystallization comes. Chemistry can do wonderful things in producing crystalline bodies. Take, for example, the acid of grapes. Till recently it was supposed to be purely the result of organized life, but chemists have shown that it may be produced from coal-gas. Now, though coal-gas is of organic origin, it is a lifeless thing, and the result is not the result of organic process. We never can produce the self-developing cell; we never can produce the independent molecular action which we call life. As has been very clearly put, while the crystallization of any crystalline body is the same to the minutest point, however it may differ to the ordinary eye, the structure of an organic substance is very different. In the case of crystals, to mathematicians the variations of crystallization are simply modifications of the same mathematical form, that may be produced with the most perfect accuracy from one to the other. It is wonderful to see a good crystallographer take a piece of a crystal and from that deduce the form of a perfect crystal. Even the smallest fragment is sufficient. But there is nothing like that in life. The same general form is seen to recur in living organisms, but there is no absolute mathematical identity. The more one studies crystallography, and sees the extreme simplicity of forms and the extreme richness of the developments of life, the more marked the difference becomes. Great as the triumphs of modern chemistry are, there is no way of infringing the boundaries of life between organic and inorganic matters, but they are left even more marked. Whatever the distinction between life and want of life, between life and inanimate nature, it is even more forcibly marked now than ever.

The Rev. R. Thornton, D.D.—I think it would be a great pity that we should not get all we can out of Mr. Howard; I am therefore going to ask a question which I have no doubt he will be able and willing to answer. I wish him to tell us his opinion about the experiments of Dr. Bastian. I was somewhat surprised at the paper read by that gentleman at the meeting of the British Association in 1871, on the "Formation of Bacteria in Animal Fluids." His statement was that these fluids were placed in glass tubes which were hermetically sealed, and then exposed to the light of the sun or to heat, when it was invariably found that bacteria had been formed. We must remember that the theory of Sir Wm. Thompson had not then been given to the world, and Dr. Bastian was evidently unacquainted with it. He stated that he had repeated his experiments again and again, and in every case

these phenomena appeared. I myself entertain very strongly the view of Mr. Howard, that life is essentially distinct from any mechanical crystallizing force; but I was rather puzzled by the statements of Dr. Bastian, and my judgment has been somewhat in suspense as to this theory of the formation of a lower order of animal and vegetable life in fluids. I hope that Mr. Howard, in his reply, will say a few words on the subject.

Mr. W. MELMOTH WALTERS.—I am also anxious to ask a question. Is not the difficulty of *comparing* crystallization with life one of our great difficulties here? In the case of crystallization we are able to analyze the substance thoroughly, but in that of life we are absolutely unable to analyze what life is. When we get to that germ there is a failure of analyzation, and therefore the comparison between the two is not complete. In the one case we are able to analyze all the parts, and to know exactly the mechanical motions that bring them together; but in the other, we have no power of analyzing the actual motive power of the whole, which is the vital spark. Therefore there is no parallel between the two cases.

Mr. J. E. HOWARD.—I shall be very happy to do what I can to answer the questions which have been put to me. The subject of biogenesis forms the title of a long paper in the "Critiques and Addresses" of Professor Huxley, and I cannot do better than refer Dr. Thornton to the passage* in which he sums up the long chain of evidence on the subject. Dr. Huxley shows very clearly, as he is well able to do when he takes a subject in hand, the deficiency of the experiments seeming to favour the doctrine, and the excellence, on the other hand, of the researches of Pasteur who takes the opposite view. The experiments in question were directed to this end: by means of various contrivances which I cannot now attempt to explain in a moment, to secure that the air which entered certain flasks should be entirely filtered from all the germs which it ordinarily contains; it was provided that the water in the flasks should be boiled (although by the way that is not sufficient, because it has been found that boiling will not destroy all the germs), and then that this perfectly pure air and perfectly pure water should be left together, and if it could be shown that perfectly pure air and perfectly pure water left in contact for a certain length of time produced living creatures, we should of course have the proof of what is called *abiogenesis*, that is to say, spontaneous generation. This controversy has been carried on to a very great extent in France, and with exceeding patience and diligence of research, and it was committed, if I remember rightly, to a certain delegation of their most learned men to decide. Pasteur completely came up to the mark with his experiments, and showed that life was not produced under these circumstances. Those who took the opposite view, I believe I may say, shirked the question. I appeal to our chairman whether that was not so.

The CHAIRMAN.—Quite so.

Mr. HOWARD.—Dr. Bastian takes the same line of view as these latter

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* Critiques and Addresses, p. 236.

gentlemen, and the controversy has been carried on by other distinguished investigators in Germany and England. The question may still be said to be upon the *tapis* in this country and perhaps in France. I can only sum it up in the way I have in this paper, that the notion of *abiogenesis* is driven as near to the vanishing point as possible. I may refer to our chairman that the tendency of the proof is against spontaneous generation. As regards what has been said by Mr. Walters, I can only say that I entirely concur with his statement of the impossibility of analyzing "the vital spark;" but the contrast between life and crystallization is greater than his remarks would seem to imply.

The CHAIRMAN.—On the subject of *abiogenesis*—that is the formation of life without previous existing life—the question is simply this. No one doubts that myriads of invisible germs of organic life are constantly floating about in the atmosphere, so minute as not to be detected; and in regard to the experiments of Dr. Bastian and others who take his view, it would appear that certain fluids are prepared which contain the elements of low organized beings, such as those called bacteria and vibriones, or contain the elements of which these animals exist, so mixed up as to be peculiarly liable to develop such a formation. The simple fact seems to be this; if you take these fluids and only take sufficient precautions to exclude the possibility of the entrance of germs, you will have no organization following, and no organized beings produced. I remember hearing a paper read at the Royal Society a short time ago, where Dr. Bastian's experiments were repeated by another professor, whose name I cannot at the present moment remember. He took elaborate precautions to prevent the possibility of any germs being present in the fluid placed in the vessels or in the air which overlaid the fluid. He took precautions which appeared to be sufficient to exclude the possibility of any germs being present. The air was passed through strong acids which would entirely destroy organic life, and the fluid was subjected to such conditions as it appears to me must have excluded any germs. And also the vessel itself, for these germs are so minute that in the ordinary washing or wiping of the vessel multitudes of them might be left behind, adhering to the surface of the glass, and which no mechanical wiping could remove. The simple result was this: wherever sufficient precautions are taken in the conduct of the experiments to prevent the admission of germs, —the fluid being introduced into a glass tube, and then hermetically sealed, so that there is no access of external air or of germs from any external sources,—the fluid will remain week after week, and month after month, without developing any organization whatever; but break the end of the tube and allow a little air in, and in the course of twenty-fours you will have, after this tube has been stationary for months without any change, multitudes of these low organized beings in it. They can only be introduced by means of germs contained in the air, and introduced into the tube when it was broken, and the external air allowed to enter it. From the recent experiments of Dr. Burdon Sanderson, the result is clear that if you take sufficient care to prevent the admission of germs into the fluids, no

organization whatever takes place. As to boiling the water, it is a remarkable fact that some of these germs do not seem to be destroyed by raising the fluid to the boiling point, but if you raise it to ten or fifteen degrees Fahrenheit above the boiling point, they are destroyed. At one time it was supposed that boiling would be a sufficient means of destroying the vitality of all germs that might exist in the fluid, but that is not so. It requires a higher temperature. But if you take sufficient pains to destroy or exclude all germs, no organization will ever take place. That is, I believe, the simple state of the case.

Mr. HOWARD.—I entirely concur in the views of the chairman, which have been much better expressed than I could have succeeded in doing.

The CHAIRMAN.—Of course this is a very vital point in the discussion of a very important subject. It is one which I have carefully considered, and upon which I have made myself acquainted with all the facts; because if you once grant the formation of one of the simplest of these bodies—these little monads—these particles of organized nature, by the mere action of inorganic forces, and grant the theory of successive development, then you may go on to something higher, then you get to mollusca, and then, according to the Darwinian theory, you may get up to man, and step by step you supersede the necessity of a Creator. That is the gist of the whole argument, and therefore the fundamental point—namely, the possibility or the impossibility of the formation of any, however lowly organized being, without the influence of a pre-existing germ. If you once admit that, all the rest follows as a necessary sequence. That is the foundation of all we feel bound to support.

Mr. NEWTON.—And hence the importance of Mr. Howard's paper.

The CHAIRMAN.—Exactly.

The Meeting then adjourned.