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Extra-Microscopic Organisms

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Those opposed to the germ-theory of disease, and especially to the application of this theory to yellow fever, abuse no argument so frequently and so satisfactorily to themselves as the one implied in their triumphant assertion that no such germ is demonstrable by the microscope: and they illogically neglect to contrast this negative argument with its equally unsatisfactory alternative, which is that the microscope, as well as chemistry, and all the appliances of physics, have also failed to demonstrate that the poison of yellow fever is either an inorganic, or a dead organic something. Now, the poison must be one of these three things, and in addition to other arguments, urged in the October number of this journal, in proof that, of the three possible hypotheses as to the nature of the poison, the germ-hypotheses was now the most rational, it will be well to understand what reasons there are, from an exclusively microchemical standpoint, for the belief that there may be living organisms very much more minute than the microscope can disclose. Confidence is felt that these reasons suffice to prove that a belief in the existence of living organisms invisible to the highest powers, attained or attainable by the microscope, is just as logical as is the universal belief in extra-microscopic atoms and molecules.

Living protoplasm is composed of atoms and molecules, and the chemical constituents of protoplasm are approximatively well known; hence, if the size of atoms and molecules, and if the least number of these indispensable to form an independent living organism, were known, it would be possible to determine how small may be the minutest organism. While science is unprepared to answer with any precision such question, it, none the less, has reached, through reasonable hypotheses, approximative conclusions, which give no countenance to the common incredulity and ridicule respecting the possible minuteness of disease-germs, and which deserve to be better known.

Since Sir Wm. Thompson's effort to determine the probable

N. Orl. M. & S. J., 1880-1, n.s., VIII, 513-515.

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"size of atoms" (Nature, March 31st, 1870), numerous other researches have been made on the subject, all tending to prove the almost inconceivable minuteness of atoms and molecules. The results of these researches, so far as they concern the present subject, have been instructively summarized by one of the highest authorities in this matter, namely, by H. C. Sorby, F. R. S., etc., in his anniversary address, as President of the Royal Microscopical Society, on the "Relation between the limits of the powers of the microscope, and the ultimate molecules of matter." (Nature, February 24th, 1876.)

Prof. Sorby teaches that "the *theoretical* limit of distinct visibility" is $\frac{1}{80,000}$ part of an inch, and that the perfected microscope of the present day has *practically* reached this limit, (some claim that even $\frac{1}{100,000}$ of an inch has been reached), so that no further improvement in this direction can be hoped for. Properly emphasizing the fact, that all calculations, respecting the size of atoms and molecules are, within certain limits, hypothetical, he none the less says: "we must conclude that in the length of $\frac{1}{80,000}$ of an inch, (the smallest interval that could be distinctly seen with the microscope) there would be about 2000 molecules of liquid water lying end to end, or about 520 of albumen. Hence, in order to see the ultimate constitution of organic bodies, it would be necessary to use a magnifying power of *from* 500 *to* 2000 *times greater* than those we now possess. These, however, for reasons already given would be of no use, unless the waves of light were some $\frac{1}{2000}$th part of the length they are, and our eyes and instruments correspondingly perfect. It will thus be seen that, even with our highest and best powers, we are about as far from seeing the ultimate structure of organic bodies, as the naked eye is from seeing the smallest objects which our microscopes now reveal to us. As an illustration, I have calculated that, with our highest powers we are as far from seeing the ultimate molecules of organic substances, as we should be from seeing the contents of a newspaper with the naked eye at the distance of a third of a mile; the larger and smaller types corresponding to the larger and smaller molecules of the organic and inorganic constituents." Farther, "calculating then, from the various data given above [omitted in these citations], we may conclude that a spherical particle

one-tenth the diameter of the smallest speck that could be clearly defined with our best and highest powers might nevertheless contain *no less than one million* structural molecules." Finally, Prof. Sorby says: "For the sake of argument, I assume that gemmules [a term used in Darwin's theory of pangenesis], on an average contain one million structural molecules of albumen, and molecularly combined water. Variations in number, composition and arrangement would then admit of an almost infinite variety of character. On this supposition, it would require a *thousand gammules* to be massed together into a sphere, in order to form a speck just distinctly visible with our highest and best magnifying powers."

Those who have been students of the phenomena dependent on the so-called "infinite divisibility of matter," and who are at the same time familiar with such considerations as the above, are surely pardonable for condemning, as an ignorant prejudice, the view that there cannot be any living organisms too minute for disclosure by the microscope; and, also, for condemning, as lacking in true scientific spirit, those who, objecting to the germ-theory, neglect to state whether the same, and even greater objections, do not hold equally good against any other conceivable theory.

While long convinced that the germ-theory of yellow fever rests on firmer ground than any other theory, I none the less have always entertained and expressed no present hope of the microscopic demonstration of this supposed germ. For, among other reasons, there has seemed to me to be little reason to hope, that the less numerous and less experienced microscopic experts engaged in researches on yellow fever—a disease which presents comparatively most unfavorable opportunities for study—would be likely to attain success, prior to the attainment of success in such diseases as small-pox, measles, scarlatina and typhoid fever, diseases which there are, perhaps, equally good reasons for believing to be germ diseases, and which so occur that more numerous and experienced experts have comparatively the most favorable opportunities for their study.

It may be well to add, that preceding facts and views constitute an addendum to my article in the October number of this journal, rather than an independent article.