THE GERM THEORY AND ITS RELATIONS TO HYGIENE.

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The following very interesting paper, by F. A. P. Barnard, LL.D., President of Columbia College, on the germ theory of disease in its relations to hygiene, was read before the American Public Health Association, on November 13. After a few excellent remarks on the general recognition, among educated men, of the universal reign of law and order, Professor Barnard said:

The germ theory of disease is not, as is commonly supposed, a theory which has originated in very recent years. More than 200 years ago it was brought forward, at least as a hypothesis, by the celebrated Father Kircher, in his *Scrutinium physico-medicum contagiosæ luis quæ pestis dicitur*, to account for the infectious propagation of the plague. However plausible this theory might at the time have seemed, it could then, nevertheless, claim no higher rank than that of a bare hypothesis; and it has only been in times comparatively recent that observation has brought to light a sufficient number of facts apparently favoring it to justify our advancing it in the arena of scientific discussion to the higher dignity of a theory.

Before proceeding to consider the evidence bearing on the truth of this theory, for or against, a few observations of a general nature may properly here find place. No living organism enjoys an existence of unlimited duration. Every such organism, under favorable circumstances, passes through three distinct stages, which are those of growth, vigorous maturity, and decline. The organism commences as a germ, and ends in dissolution and disintegration. Since the laws of life, as well as those of physics, are fixed and definite, there is reason to believe that all organisms of the same species, if placed in conditions equally favorable to their development, would be equally long-lived; yet, in point of fact, those which pass through the regular stages constituting their normal life are comparatively few. In the large majority, the vital functions are, earlier or later, more or less disturbed, if not arrested, by an endless variety of causes tending to produce disease and premature death. In the human race, life is often shortened by ignorant or wilful disregard of the conditions necessary to the preservation of health. Accident, also, often exposes individuals to deleterious influences. Thus, in many cases, diseases arise from exposure to extremes of temperature or from excesses in eating and drinking, persisted in until the organs of digestion become debilitated and fail to fulfil their proper functions. But beside these causes of disease, which may be classed under the head of "injurious conditions," there are other influences directly morbific, which, whenever they come into play, cut short the duration of life. Poisons belong to this class, but the effects of these are felt only in occasional and accidental instances. Other noxious influences, of which the pernicious consequences are more widely spread, are those which produce the diseases called zymotic. Such are malaria, contagion, and infection, instrumentalities to which are owing the widespread ravages of epidemic.

It may be remarked that there are many cases of disease in which the cause is not traceable directly to any of the sources above mentioned, but in which the disease has been transmitted by inheritance from a parent similarly affected. In such cases there is nevertheless every reason to believe that the disease in its first appearance was produced in a healthy organism by causes belonging to one or the other of the classes above named.

The diseases which it is the object of the present paper to consider are only those which belong to the epidemic or contagious class.

THE EPIDEMIC OR CONTAGIOUS CLASS OF DISEASES.

No subject has occupied more the careful attention of physicians, or has been a subject of more elaborate observation and experiment, or has led to more marked difference of opinion or more animated controversy, than that of the nature of the influences by which these diseases are transmitted from individual to individual. That many epidemics arise from peculiar conditions of the atmosphere, not in the least as yet understood, can hardly be doubted; and in this case the influence which excites disease simultaneously in many is not dissimilar to that by which contagious diseases are transmitted from individual to individuals. Two theories, distinctly opposed to each other, have long been held on the subject. These may be distinguished as the chemical theory of infection and the germ theory. The chemical theory is founded on a presumed analogy between the propagation of disease in living organisms and the process of fermentation in certain forms of organic matter without life. This theory assumes a ferment to be an organized substance in a certain state of decay, which possesses the property of exciting the same decay in other organic substance with which it is in contact. Applying this theory to disease, it supposes that infection is communicated by the instrumentality of particles thrown from the person, or from substances proceeding from the person diseased, and borne by the air to other persons in full health, in whom they excite, probably by contact with the membranous linings of the lungs, the same diseased condition which exists in the patient. The opposing theory presumes that the diseased person is suffering from an invasion of his system by microscopic algoid or fungoid vegetative forms having the property of rapid self-multiplication, and that the spores which proceed from these fungi or the cells of the algæ are wafted in like manner by the air from person to person, penetrating the systems of the healthy, and establishing new colonies to generate disease in them.

A *prima facie* evidence, which so far as it goes is favorable to the germ theory, is found in the well known fact that all the forms of cryptogamic vegetation are propagated by spores, which they shed freely abroad in all directions, and that these are borne in infinite numbers through the atmosphere, which they pervade near the surface of the earth in all places. The fact of their universal presence is made manifest by the promptitude with which fungoid growths spring up in all circumstances in which the conditions favor their development. We know that the numbers of spores which all fungi produce are incalculable. The larger fungi give us evidence of this. The spores of a single puff ball have been estimated to be more numerous than the entire human population of the globe. It is true that to ordinary observation the presence of foreign matters in the atmosphere is not perceptible, except when such foreign matters take the gross form of clouds of smoke or dust; but particles of smoke or dust, and in general of all inorganic substances, are so heavy that they soon subside; yet when the air is thus left apparently free from all foreign admixture, it is demonstrably full of organic particles so extremely light as not to subside for many hours or even days of perfect rest. The chemist, it is true, is unable to detect them by his tests, delicate as they are; for being organic, and composed in general of but two or three elements—which elements are in great part those of the atmosphere itself—they produce no distinctive reactions under the ordinary processes of analysis. But there is a mode of analysis much more delicate than even that of the chemist. It is that which has been applied incidently to this question by Professor Tyndall, in his interesting investigation into the chemical effects of light upon vapors. Professor Tyndall discovered that there are many substances of great volatility which, when in the state of vapor, are easily decomposed by light. He found that a perfectly transparent vapor-like steam, when traversed by a luminous beam, is absolutely invisible; while we all know that if we admit a beam of sunlight into a darkened room, through an aperture in the shutter, the path of the beam through the apartment is as distinctly marked as if it were a solid bar. That this visibility of a beam of light in the air is not owing to the power of the aerial particles themselves to reflect light, is demonstrated by him by proofs entirely conclusive A beam of light from an electric lamp was made in his experiments to pass through a large glass tube closed at both ends by plates of glass, ground on. No light was permitted to escape into the room; and, accordingly, when the tube was exhausted of air altogether, and no light from its interior was reflected to the eye, it was perfectly invisible. But if the air of the room were allowed to re-enter it, it immediately became brilliantly luminous, as in the case of a sunbeam admitted through a window shutter. He showed, however, that a filter of rather closely compacted cotton will shut off entirely, or almost entirely, the organic matters which the air contains; and he showed, finally, that absolute rest for a long period of time will cause these particles completely to subside. He constructed a closed space, cubical in form and several feet in linear dimensions, glazed so as to permit him to pass through it a beam of light, and to observe the path of the beam. This small apartment was made absolutely airtight, and left to itself. On each succeeding day the brilliancy of the transmitted beam grew less and less; and at length, at the end of a week, it could no longer be perceived at all. The apartment was optically empty.

THE AIR FILLED WITH ORGANIC MATTER.

It is not necessary to suppose that all particles of organic matter are living germs of vegetable or animal organisms; but when we see how constantly such organisms spring up wherever the conditions favor germination, it is impossible to doubt that a vast many of them have this character; and that these are the source of those growths of minute cryptogams which thus seem to spring up spontaneously. There is no mode of accounting for such growths, except to suppose that they are actually spontaneous; and accordingly the view has been taken by some physiologists, perhaps I should say many, that the true mode of accounting for the appearance of microscopic forms of life is to suppose that they originate without organic antecedents, or as they expressed it, *de novo*. No question at the present day is more sharply debated than that which relates to the origin of life. There is no subject which has been pursued experimentally with more zeal, more earnest solicitude to reach the truth, and with more singularly discordant results than this. The notion of spontaneous generation, is not, by any means, of modern origin. It has been entertained by naturalists in every age since the dawn of scientific history. But the earlier naturalists, Aristotle and Lucretius, for instance, conceived that organisms of a high order of complexity, such as insects, or fishes, or reptiles, might be directly produced out of the moist earth softened by showers, or out of the slime and mud of rivers; whereas those of our time have long since abandoned any such extravagant notions, and confine themselves to the assertion that life in its spontaneous origin is manifested only under the simplest forms.

Less than three centuries ago the belief that living things may originate without eggs, or germs, or living parents from which to proceed, may be said to have been universal in Europe. Of the truth of this belief there was supposed to be visible evidence in the invariable occurrence of maggots in putrefying flesh. The doctrine was held as matter of faith, and those who first assailed it were naturally accused of impiety and irreverence. Prominent and perhaps first among these was Francis Redi, an Italian philosopher, scholar and poet, born in 1626. He presented a conclusive disproof of the spontaneous generation of maggots in putrefying flesh, by simply inclosing, in an open mouthed jar covered with gauze, pieces of flesh still sound, and leaving them in the sun to putrefy. Putrefaction occurred as before, but no maggots made their appearance. The maggots, nevertheless, did appear on the gauze, and a little observation made their origin manifest. The flies, of which they are the progeny in the larval state, being attracted by the odor of the flesh, but unable to reach it, laid their eggs upon the covering of the jar, and out of these the larvæ were presently developed. Having demonstrated the falsity of the popular belief on this subject in a case so conspicuous, Redi naturally generalized his conclusion, and took the ground that no living thing comes into existence without deriving its life from something previously living. He did not say, as it has been said later, "*omne vivum ex ovo*," but "*omne vivum ex vivo*." He still believed that out of a living plant may arise a living animal, as the insect within the gall of the oak, or the worm within the fruit which presents no external puncture. His doctrine was, therefore, that which Huxley has named *biogenesis*, in contradiction to spontaneous generation, called by him *abiogenesis*, and by Bastian *archegenesis*. But *archegenesis* had been put aside only to return again under a new form. Among the earliest revelations of the microscope was the remarkable fact that, whenever a dead organic substance is infused in water, myriads of minute creatures presently make their appearance in the infusion, all possessing most extraordinary and many of them very varied powers of reproduction. They multiply by means of *ova*, by means of buds, or gemmation, and by means of self-division, or fissuration. All this was strongly favorable to the doctrine of *biogenesis*. Where so many means of reproduction existed, every one of them so effectual and sufficient, to provide that the same forms of life should be produced without any organic antecedents, seemed "wasteful and ridiculous excess," This view, however, met here and there with a dissentient. About a century and a quarter ago, John Thurberville Needham, an English naturalist, resorted to an experiment which, with various modifications, has been since repeated many hundreds, possibly many thousands, of times, with the view thoroughly to test the question whether, in its application to infusorial life, the doctrine of *biogenesis* is universally true. He prepared an infusion, thoroughly boiled it in a flask, corked it tight, sealed the cork with mastic, and covered the whole with hot ashes, designing to destroy by heat any germs which might be in the infusion, in the substance infused, or in the air above the liquid in the flask. After some days or weeks, he found that, notwithstanding all these precautions, living organisms did make their appearance in the flask, precisely such as, in freely exposed infusions, habitually appeared earlier. This experiment was immediately repeated by Spallanzani, an Italian ecclesiastic and naturalist; but Spallanzani, instead of corking his flask and cementing his corks, sealed the vessels by fusing the glass; and having thus completely cut off communication with the outward air, kept them at the boiling temperature for three quarters of an hour. No life appeared in the infusions of Spallanzani, and the doctrine of *biogenesis* was again apparently triumphant.

Marbled Paper.

This, much used by bookbinders, is produced in a very curious way. The name is not exactly suitable, seeing that few of the specimens are imitations of real marble; but it has gradually become applied to sheets of paper of which one surface is made to imitate any kind of stone or wood. Small brown spots on a light ground, marble veining on a shaded ground, curled patterns and wavy patterns, all are produced in great diversity. The colors are of the usual kind, such as Naples yellow, yellow ocher, yellow lake, orpiment, verdigris, rose pink, red lead, carmine, *terra di Sienna*, Dutch pink, indigo, Prussian blue, verditer, umber, ivory black, etc.; they are ground up very fine with prepared wax and water and a few drops of alcohol. A solution of gum is made of gum tragacanth, alum, gall, and water, and placed in a trough or shallow flat vessel. Color is thrown on the surface of this gum water, usually by striking a brush against a stick, so as to produce a shower of sprinkles. Pigments of different tints and different thicknesses or degrees of consistency are thrown on; some spread more than others, and thus a diversity of patterns is produced. Sometimes the color is thrown on by means of a pencil of very long bristles; it is diversified by means of a rod, held upright and carried along amongst the colors in a wavy or spiral course; and it is further cut up into tortuous lines by passing a kind of comb along it. All this takes place on the surface of the gum solution in the vat. When the vat is prepared, a sheet of paper is laid down flat on the solution, care being taken that every part of the surface shall be wetted; the paper takes up a layer of paint, fancifully disposed in a pattern or device, and is hung up to dry. In order that one color may not be blended or confused with another, they are ground up with different liquids, some watery, some gummy, some oily. The imitations of marble, gray and red granite, and fancy woods, are certainly not very faithful; but the paper is lively in appearance, and remains clean and bright a long time when polished. This polishing is effected by moistening the colored surface of the paper with a little soap, and rubbing it with a piece of smooth marble, an ivory knob, a glass ball, or an agate burnisher. Beautiful products have been produced within the last few years under the names of iridescent and opalescent paper. Like the commoner kinds, these receive colored devices on one surface; but great delicacy and care are called for in the processes to produce the exquisite play of light and shade which suggests the names given to these varieties.—*Practical Magazine.*