main river, it is additionally necessary that the Bridgeport pumps be continuously operated.[1]

From causes already indicated, — namely, by the more perfect utilization of wastes and refuse which formerly added to soil and water contamination, and by thorough sanitary supervision and control, — it is probable that the pollution of the Chicago River will be due mainly, in the future, to the sewage proper of the city. This, of course, will increase with the increase of population and the extension of the sewer system. But I estimate, that, at the present time, the river and its branches may be kept in a fair sanitary condition, and the sewage diluted so as to be inoffensive, by causing a flow of from forty-five to fifty thousand cubic feet per minute through the canal: sixty thousand cubic feet will probably be sufficient when the population has increased to seven hundred and fifty thousand. If, by the time the present capacity of the canal is reached, the proposed plan of converting it into a ship-canal has not been realized, it may be necessary to seek additional relief through the Des Plaines River. Pumping-works at the 'Ogden ditch,' discharging into the Des Plaines, may then be used to supplement the discharge into the canal; and for many years these two systems will be adequate to prevent any serious pollution of the Chicago River, will protect the water-supply from contamination, and will relieve neighboring communities along the canal and Illinois River from the nuisance heretofore frequently caused by the sewage-disposal of Chicago.

JOHN H. RAUCH.

[1] The Fullerton-Avenue conduit was constructed, and the pumping-works arranged, so as to discharge the contents of the north branch into the lake through the conduit, or to convey lake-water into the branch. The former method is contrary to the correct principles of the sewage-disposal of Chicago, and must ultimately be abandoned.

SOILS AND HEALTH.

THE soil, especially the first few inches or feet below the surface, is the ante-chamber of life, — the laboratory in which operate incessantly the processes by which inert matter is prepared for the nourishment of life. It is this, because it is also the tomb of all terrestrial living matter. Here is the realization of the Phoenix-myth; the slow combustion of organic matter leaving a residuum, from which springs the new life of succeeding generations.

These processes of the transformation of matter are the work of the low forms of microscopic life which are known as bacteria, and are gifted with the capacity of enormous and immensely rapid multiplication. This world of microscopical life is vast as regards the distribution and number of its living entities. These minute organisms are known to be intimately connected with many of the fundamental processes of the organic world, and our knowledge of their range of activity is constantly increasing.

They may be considered practically to stand in close genetic relations to many diseases; but the question of absolute differentiation of forms with specific functions, or of the possibility of Protean functional characteristics among them, varying with their surroundings, is one of the present great problems of biology.

The great majority of pathologists now consider the infectious, and most of the contagious, diseases to be dependent on these low forms of life; and the tendency is, to consider that certain diseases or groups of diseases are produced only by specific forms of bacteria.

These organisms are wide-spread, especially the various forms that are associated with putrefaction and mould. Only on high mountains, and far from land on the ocean, is the air practically free from them. Elsewhere the air, water, and soil teem with them. Their abundance is necessarily proportionate to the amount of decomposing organic matter in the neighborhood, since they are themselves the scavengers, on which the processes of decomposition depend.

Few people realize what an important part the soil plays in our lives. The water we drink (unless from cisterns) has leached through it. The air we breathe is frequently loaded with its dust. It is in our food.

The soil is highly porous; and the interstices between the grains are filled with water or with air, — 'ground-water' or 'ground-air.' The ground-air fluctuates with the varying barometric pressure, and with the rise and fall of the ground-water in rainy and dry seasons. The ground-water flows according to the common laws of hydrostatics, but with a movement retarded by friction.

A town on a river-flat is built over a continuous sheet of slowly moving subterranean water, and most houses are built where water is accessible within a few feet from the surface. In view of the fact that our wells and the cellars of our houses are in more or less close proximity to these centres of pollution, it was thought desirable to ascertain to what extent the different soils act as filters in arresting the spores of bacteria. This investigation, which was carried out for the National board of health by the writer, assisted by Dr. Smyth, brought out very clearly three facts: —

I. All soils finer than very coarse sand have practically a continuous capacity for arresting the spores of bacteria from infected *air* filtering through them.

II. No soil, no matter how fine, can arrest and hold back the spores of bacteria contained in *water*. The experiment on which this statement rests consisted in filtering unsterilized water through one hundred feet of pipe filled with fine sand which had been sterilized by heating to a red heat. This pipe was connected by an air-tight joint with a flask of sterilized beef-infusion, and the whole apparatus left for several weeks before use. The first drop of water that passed through these hundred feet of sand infected the beef-infusion, causing it to putrefy.

III. Neither bacteria nor their spores can detach themselves from a liquid or from a wet soil, and pass into the air, except through the conversion of the water into spray, or through the formation of dust by evaporation.

The chief practical inferences from these results are, that distances, even of hundreds of feet, between wells and cesspools, are no protection against infection, and that a dry or an alternately wet and dry cellar may be more dangerous than a permanently wet one.

These results emphasize the importance of an intelligent survey of the condition of the soil in selecting a home, and of a legislation prohibiting the pollution of the soil.

In many towns and cities, the privy-vaults and leaching cesspools of every house drain really into the sheet of ground-water: the soil arrests the coarse material, the grease and slime; but the swarming bacteria diffuse with ease, as much as the soluble chlorides and nitrates, and follow the flow wholly unobstructed. Into this same soil are sunk or driven the wells; and the water that is drawn for use is polluted in proportion to the number and proximity of the vaults and cesspools, on the one hand, and the thinness and sluggishness of the water-sheet, on the other. In the worst wells in daily use, the water is distinctly colored with sewage; but the most deadly water may carry only the germs of typhoid-fever or of dysentery, and be otherwise sparklingly clear, and so pure as to pass unchallenged through the most searching chemical analysis.

If the soil is polluted and very coarse gravel, this indraught, loaded with the spores of bacteria, will flow through the cellar to the warmer rooms. If the soil is polluted and fine, and the ground water-surface rises at any season to the level of the floor, or higher, it will evaporate as it oozes into the cellar, and leave an infected dust to be taken up into the circulation of the house-air. Similar results will follow from the leaching of the cesspool toward the cellar-wall, or from the filtration through the soil of sewage from a broken or leaky drain; which is very apt to exist in or just outside of the foundation-wall. The pollutions of soil and water already mentioned are of such a general character, that, with ordinary forethought, they can be guarded against; but there are others of a local character which are not revealed to a general survey. In the growth of many of our cities, the natural topography is disregarded. Lowlands and marshes which are traversed by sewage-fed brooks are covered with a network of high-graded streets, which convert the blocks into sewage-basins, which come, in time, to underlie blocks of dwellings of all classes.

In other cases, low or marshy ground is made the dumping-ground of the city, and receives the sweepings of the street, the contents of the ash and garbage barrels, — every thing, in fact, that cannot pass through the sewers or be sold. The entire material is loaded with organic matter which is kept in a state of very slow decomposition by moisture.

Some of the costliest dwellings of our cities rise upon such soil. We may take every precaution to avoid in our homes the dangers that arise from a polluted soil, and may yet fall victims to the filthy condition of remote places, over which we have no control.

Among many others there are two exceptionally frequent sources of danger of this kind. One of these is the farmer's well, which is rarely safe, and, when not used to adulterate milk, is used to rinse milk pans and cans, and leaves upon their surfaces a source of contamination. The other frequent instance is the use, by druggists, of water from wells or from cisterns, which are often any thing but sewage-proof. Throughout the country, and often in the cities, the use of only distilled water in compounding medicines is far from universal; and I have had analyses made of lime-water bought at a druggist's, which was highly contaminated with organic matter. The druggist's well, moreover, is the source of most of the soda-water throughout the country, as well as in many cities where the water-rates are high. A person having a harmless disturbance of the bowels, arising from a cold, is just in the condition to succumb to the dysentery or typhoid-fever lurking in the medicine or Vichy-water from the too-much-trusted druggist.

RAPHAEL PUMPELLY.