home, or imported, the testimony is uniform that epidemics of yellow-fever have their starting-points in the lowest, filthiest quarters of seaport towns, than which nothing can be filthier or more disgusting. It can hardly be necessary to dwell upon this point. With the improvement in the water-side precincts of New York, Philadelphia, and other North-Atlantic seaports, yellow-fever has ceased to be the devastating pestilence which it was in the days of Benjamin Rush. In those days the purlieus of such cities were little better than they now are in the towns and cities of the Spanish main, where it still rages. In the latter, it is true, there is always present the added factor of a favoring condition of temperature; and, less constantly, this also affects our Gulf and South-Atlantic seaports. But this of itself should be an additional incentive to securing the best attainable sanitary condition. Foul drains, filthy streets, reeking gutters, neglected cloacae, excremental accumulations, decomposing garbage, rotting fruit and vegetables, the drainage of sugar and molasses casks, — the wonder to the sanitarian, as he views such scenes for the first time under the tropical rays of a summer sun, is not that yellow-fever occasionally occurs, but that pestilence in some form is not always present. In the endemic home of yellow-fever, 'sanitation' is an unknown term; and, in the degree that its import is ignored along our Gulf and South-Atlantic coasts, the disease finds favorable conditions for establishing itself whenever its poison is introduced.

An obvious precaution is suggested by the fourth proposition, — that yellow-fever is a disease of cities and crowded populations.[1] As a rule, it is limited not only to cities, but to sharply defined quarters of cities. The great specific gravity of the poison, and its property of clinging to surfaces, are shown in this limitation of extension. Frequently its rate of progress may be mathematically defined, so many feet per day, independent of any recognized influence, except a perpendicular obstacle. A board fence has been known to stop its progress, as in Mobile; or a bluff bank to hold it at bay for weeks, as in Memphis. Not only do the higher portions of a city suffer less than the lower, other things being equal, but the upper stories of individual houses are safer than the lower. Yellow-fever is essentially a local disease, its existence depending upon particular circumstances of place: hence, when the disease manifests itself in a locality, the imperative duty of the sanitary authority is to remove from the infected place (be it house, street, ward, or quarter) all those susceptible to it, — to depopulate the infected district, if it tends to become epidemic, by removal to camp, if only a few miles distant, as was done with such satisfactory results in Memphis during the epidemics of 1878 and 1879, and repeatedly before that time in the U. S. army. The *cordon sanitaire* may be employed to prevent people from going into an infected district; but with the present resources of sanitary science, and definite knowledge of this disease, its use to prevent escape from such a district is a barbarism of the same character as the old-time quarantine of detention.

In a word, the precautions to be taken against yellow-fever are the same as those which common sense and experience have shown to be adequate against the other exotic infective diseases: to wit, a thorough system of sanitary supervision and control of intercourse, both by sea and land, for the exclusion of the specific poison; and, supplementing possible (if not inevitable) defects in this, the destruction of the conditions necessary to the life and activity of the poison by general and local sanitary effort within our own territory.

F. W. REILLY.

[1] Its occasional extension to small places, and even to plantations and isolated houses, does not affect the general accuracy of this proposition. Such extension occurs only during widespread and virulent epidemics, when, it may be inferred, the specific poison is generated in such quantity and intensity as to be the more readily transplanted from place to place.

CHICAGO-RIVER POLLUTION.

IT is worthy of note that the first sanitary regulation made by the authorities of the town of Chicago had reference to the protection of the river from pollution. Nov. 7, 1833, the town trustees declared it to be unlawful "to throw or put into the Chicago River, within the limits of the town, any dead animal or animals, under a penalty of three dollars for every offence." More than half a century later, the problem of establishing and maintaining an inoffensive condition of this stream still demands the attention of the sanitarian. A glance at the topography of the region will facilitate comprehension of the problem, and assist in its solution.

While the western portion of Cook county is embraced in the general slope of the watershed of Illinois and the interior system of drainage of the State, — which is to the south and west, and ultimately into the Gulf of Mexico, through the Mississippi River, — the region of Chicago, embracing the greater portion of Cook county, drains naturally into the Gulf of St. Lawrence, through the Great Lakes

and the St. Lawrence River. The site of the city was once covered twenty feet or more by the waters of Lake Michigan, whose western rim, at no very remote period of geologic time, was some eight or nine miles west of its present position with reference to the city of Chicago. The recession of the lake resulted in the formation of a series of sand-dunes or ridges, with intervening ponds and lagoons, which gradually filled up with the humus of peat-producing vegetation. This formation was the original site of the city, with an average elevation of only twelve feet above the lake, and much of it being so low as to be subject to overflow, even by the ordinary variation of the lake under the influence of north and north-east winds.[1] Through this low, flat, swampy plain there eventually cut its way to the lake a narrow, sluggish stream, the present Chicago River. Forking about a mile and a half from its present mouth, its north branch runs in a direction generally parallel with the lake shore for a distance of some twenty miles; while its south branch, after running due south for about two miles, tends sharply to the south-west for a mile or more, and then divides into two smaller branches, the western one of which is separated from the Des Plaines River by a narrow 'divide' of only a few feet elevation. In seasons of high water, this 'divide' was formerly obliterated by the flow of the Des Plaines into Lake Michigan, and for several years an artificial communication has existed between these two streams through the so-called 'Ogden ditch.' In 1848 the Illinois and Michigan canal was completed, connecting this south branch of the Chicago River with the Illinois River at La Salle, ninety-six miles south-west; and in 1871 the summit-level of the canal, twenty-six miles long, had been lowered from twelve feet above, to eight feet and a half below, the ordinary level of Lake Michigan: so that, theoretically, the Chicago River now rises in Lake Michigan, and empties into the Mississippi through the Illinois and Michigan canal and the Illinois River. The primary object of the construction of this canal was purely commercial, but it has since become one of the most important factors in the sanitary welfare of the city.

As the cholera epidemic of 1849–50 led directly to the introduction of lake-water, and the foundation of what is, in some respects, now the most magnificent system of water-supply in the world, so the repeated epidemics of cholera and dysentery led to the adoption, in 1856, of a system of sewerage, which, within twenty-four years thereafter, had furnished more linear feet of sewers *per capita* of population than in any other of the large cities of the Union. For fourteen years (1843–56 inclusive[1]) the average annual death-rate of the city had been 37.91 per thousand, probably the highest of any city in the United States; during the first fifteen years of sewer-construction (1856–70), the average annual death-rate was reduced to 23.97 per thousand; while, from 1871 to 1884 inclusive, the average has still further fallen to 21.40 per thousand. And although there have been marked fluctuations from year to year, — rising to 32.22 in 1866, and falling to 16.49 in 1878, — on the whole, there is, as I have shown in a table published elsewhere,[2] a striking correlation between the annual death-rate and the number of feet of sewers *per capita* year by year, independent of all other influences.

But while the sewerage of the city has been one of the most important agencies in this reduction of the death-rate, it has necessarily added to the pollution of the river and its branches, and from time to time has affected the purity of the water-supply. To such proportions did this evil speedily attain, that in July, 1860, — only four years after the system was adopted, — the sewerage commissioners recommended that the canal be deepened and enlarged, so as to create a constant current from the lake into the Illinois River, as a measure indispensable to the protection of the health of the city. The recommendation was not heeded at the time; and for some years thereafter, Mr. Chesbrough, the sewerage engineer, continued to urge, as a practical measure of temporary relief, the construction of covered canals or aqueducts from the lake, with apparatus for forcing lake-water through them into the north and south branches respectively, and so to create a current from the river into the lake, pending the construction of a system of intercepting sewers or the deepening of the canal, — both of which measures he had ably discussed from time to time, from the year 1855.

Meanwhile the volume of sewage and of offal from the slaughter-houses and other sources, pouring into the river, continued to increase with alarming rapidity; and although the foul-

[1] The highest point above the level of Lake Michigan, for fifteen miles north, is only thirty-eight feet; and south-east for the same distance, only twenty-three feet. Directly south of the city, the surface is almost level, the highest point within sixteen miles being only twenty-two feet. Southwest for ten miles the highest point is only ten feet, where, at the Summit, the waters of the St. Lawrence run north-east, and those of the Mississippi south-west. From the Summit there is a gradual descent, until the ground is lower than the surface of the lake.

[1] Certificates of causes of death were first required in 1841, but records were not begun until June 1, 1851.

[2] 'The sanitary problems of Chicago, past and present.'

ness was occasionally mitigated by the action of the pumps at Bridgeport, raising water from the south branch into the canal as needed for navigation, it was not until the spring of 1865 that it was finally decided to deepen the canal, as had been recommended in 1860. A remarkable epidemic of erysipelas, which prevailed exclusively along the south branch and main river in 1863, and which was obviously caused by the unspeakable filth of these streams, had undoubtedly much to do in securing this decision; but the efficiency of this mode of relief had been incidentally shown by the action of the pumps at the head of the canal. The work was begun in the fall of 1865, and completed in July, 1871; but even before it was completed, the water-supply, taken from a point about one-fourth of a mile from the shore, had been so often affected by the current from the river, that a tunnel under the lake, running out two miles farther, was constructed, for the purpose of getting the supply from beyond the area of river-pollution.

Relying upon the deepening of the canal to establish and maintain a cleansing current from the lake through the river, the pumps at Bridgeport were removed when the 'deep cut' was completed, notwithstanding which there was for some time a decided improvement in the condition of the river. Gradually, however, the increased sewage-production of the rapidly growing city, a diminution of flow through the canal due to various causes, and the fluctuations of the lake-level, indicated the necessity for further effort.[1] In 1871 the construction of the 'Ogden ditch' was begun; and after its completion another factor was added to the problem, — a factor which acquired additional importance, when the dam and flood-gate intended to regulate the flow through the ditch were broken down, and became inoperative. The Des Plaines pours through this ditch into the south branch a volume often greater than the entire capacity of the canal. Every cubic foot of this water reduces by so much the inflow of the lake through the main river and south branch into the canal, and thus causes a concentration of the pollution.

In 1881, after careful study of all the conditions, I urged the re-establishment of the pumping-works at Bridgeport, recommending that their capacity be made sixty thousand cubic feet per minute, and subsequently pointed out the necessity for the re-establishment of the dam at the 'Ogden ditch.' An appropriation was promptly made for the pumping-works, and these were completed late in the fall of 1883; but thus far they have not pumped over thirty-five to forty thousand cubic feet per minute. Within a short time an appropriation has also been made for the repair of the dam.[1]

At the present time the fouling of the river and its branches from the blood, offal, and wastes of the slaughtering and packing establishments and their subsidiary industries, has been materially reduced by the utilization of much which was formerly considered worthless, and consequently was thrown into the river or upon the surrounding prairies. On the other hand, the volume of sewage proper has increased with the growth of the population and the extension of the sewered area, until a daily sewage-production, which may be roughly estimated at from forty-five to fifty million gallons, is now poured into the river and its branches. With the exclusion of the waters of the Des Plaines River from the canal, and the continuous operation of the pumping-works, this sewage need never be allowed to find its way into the lake, except for a short time during the spring thaws, or as the result of unusual rainfalls; and these exceptional occurrences will not then entail serious consequences, owing to the permanently improved condition of the river and its branches, resulting from the continuous removal of the sewage, and the cleansing effect of the steady influx of lake-water.

It should be stated that provision is made for the purification of the north branch of the river, as originally suggested by Mr. Chesbrough, through a conduit from the lake, with pumps capable of pouring eighteen thousand cubic feet of water per minute into the branch at Fullerton Avenue. To prevent this from creating a current into the lake through the

[1] The lake is highest in July and August, and lowest in December and January, the average fluctuation being about three feet. Occasionally it is much greater than this: for example, on one occasion in February, 1875, the stage of water at the head of the canal was only five feet and eleven-hundredths, while for a short time in April, 1877, it was fourteen feet. Local rains on the watershed of the south branch, or on the area drained by the summit-level of the canal, or high water in the Des Plaines pouring into the south branch through the 'Ogden ditch,' — all operate, to a greater or less extent, in the same way that a low lake-level does; that is, the current in the south branch and main river is suspended or reversed, and, instead of flowing off through the canal, the sewage is carried into the lake in dangerous proximity to the in-take of the water-supply at the 'crib.' This condition obtains every spring for varying periods, and during the spring just closed it was frequently observed. A local rain on the 2d of this month (June) created a current from the river, which continued for several days, the effect being perceptible for some distance beyond the 'crib,' until counteracted by north-east winds.

[1] When this is completed, it may be necessary to convey the flood-waters of the Des Plaines to Lake Michigan, at some point north of the city, in order to obviate the danger of inundating the town of Joliet by freshets from a watershed of some twelve hundred square miles. This, however, and the treatment of local areas, are matters of detail which present no features not easily mastered; as, for instance, the fork of the south branch which runs near the Union stockyards, now a foul cesspool. To bring this within the general system requires that an adequate volume of lake-water be poured continuously into the head of the fork, washing its contents, properly diluted, into the south branch, to be thence pumped into the canal.

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: —