EPIDEMIOLOGY;

OR, THE

REMOTE CAUSE OF EPIDEMIC DISEASES IN THE ANIMAL AND IN THE VEGETABLE CREATION.

WITH THE CAUSE OF HURRICANES, AND ABNORMAL ATMOSPHERICAL VICISSITUDES.

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INTRODUCTION.

As the causes hitherto assigned for the production of epidemic diseases, are insufficient to account for either their origin or subsequent diffusion—as more particularly shown in the first part of this work—it becomes an important question to ascertain, what is the real, the efficient, cause of this class of diseases. This is a subject, that would be interesting at any time and under all circumstances, but it is particularly important at the present moment, for we are now living in an epidemic period, or pestilential epoch. Of this fact, there can be no doubt; while it will be rendered apparent to the commonest understanding hereafter. Independently of the scientific interest attached to such a subject, it is of still more importance in a practical point of view: the success of the measures, that may be adopted for the prevention of disease, being dependent on the views that are entertained respecting the cause of its production. If the theory be false, the measures based on its acceptance will be either useless or injurious. This has actually been the case of late. As is well known, the principal measures now adopted in England, for the prevention of disease, are derived from what is termed sanitary reform. By this is meant the removal of putrescent substances on the surface, and the supply of pure drinking water, *i.e.* free from the presence of organic and decomposing matter; it having been assumed, that all diseases, epidemic and endemic, are to be referred to the products of decomposition, present either in the air or in water. Hence, it has been termed by me the "organic theory:" the term sanitary reform being, as we shall presently find, a misnomer.

Now it might be supposed, if this theory were true, that nothing could be easier than to lessen the effects, and prevent the return, of endemic and epidemic diseases in future. This, in fact, is what we were told, and what we were promised, on the inauguration of sanitary reform. "I would express my conviction," observes Dr. Southwood Smith, the founder of this system, "derived from much observation, and some experience, that the most distressing of the evils of which we have been speaking (the prevalence of disease) are capable of being *almost entirely prevented* in future." * The members of the then Board of Health, in 1849, also expressed themselves in similar terms:—" Upon the whole we submit, that the facts and results given in this report, have placed in the hands of the Legislature, for administrative execution, measures for checking the progress, and lessening the severity, if not *entirely preventing*, the occurrence of this pestilence (viz., cholera): and that the measures preventive of this one epidemic, which only attacks, at distant intervals, some of our towns and cities, are preventive of typhus and other epidemics." Nevertheless, we have had two visitations of the epidemic cholera since—each more severe than the preceding—while two other new diseases, viz., diphtheria and typhoid fever, have made their appearance in the interval. In addition to this, all ordinary

* *First Report of the General Board of Health.*

diseases have gradually increased in frequency and intensity, from the date of the introduction of sanitary reform to the present day.* Do these two events, then, stand in the relation of cause and effect; or, is their simultaneous occurrence merely a coincidence? The latter is, no doubt, the fact; but, then, the subsequent increase of all diseases, in England, and the appearance of three new ones, show, very clearly, that sanitary reform has failed, after a trial of fifty years, to produce any beneficial effect. It is stated, that disease has been diminished, in this or that locality, by the adoption of sanitary measures; but the results, it will be found, when investigated, are dependent on causes altogether extraneous to those to which they are usually referred.

A striking instance of this has been lately afforded. Dr. Sutherland, referring to the health of the British troops in India, remarks: "There is nothing more remarkable than the advance of sanitary improvements in India, during the last ten or twelve years." And he adds: "At the time, when the Royal Commission on the sanitary state of the Indian army began its inquiry, in 1859-60, the average death-rate, among British troops in India, was 69 per 1,000. Last year, it was a shade over 13½." † This statement is a very extraordinary one, emanating, as it does, from a member of the Indian Sanitary Board, in England; and who, we might have inferred, would have made himself acquainted with the previous medical history of the Indian army. Had this been done, Dr. Sutherland would have found, that the ratio of mortality, in 1860, instead of being 69, was 31·30 per 1,000—less than half. Equally erroneous is the conclusion, that the

* See the Statistical Tables contained in the First Part of this Work, pp. 119—122.

† *The Lancet*, Nov. 27th, 1875.

reduction in the rate of mortality in India, observed of late years, has been caused by the introduction of sanitary reform. These errors were pointed out, by Dr. Macnamara and by myself, in subsequent numbers of the *Lancet;* but similar false conclusions having been drawn, in a paper read at the Society of Arts, April 21st, 1876, I was induced to send a reply: the substance of which was as follows:—*

In this Paper, read by Captain Douglas Galton, it was stated; "The death rate of the British army, in India, averaged, in old times, 69 per 1,000: while, from 1830 to 1845, the deaths of the European army in Bengal averaged 67 per 1,000, of which number 58 per 1,000 were from zymotic disease." † It has also been stated, in the Report of the Royal Commission, on the Sanitary State of the Army in India, before referred to, that "the annual rate of mortality has been 69 in the 1,000, *during the present century,* on the average." The same rate was given by Miss Nightingale, in a Paper read by Sir Harry Verney, at the Social Science Congress, in 1873: this rate having been adduced, both by this Lady and by the Royal Commissioners, on the authority of Mr. Annesley. Undoubtedly, this was about the rate—63 per 1,000—given by Mr. Annesley, but, then, under what circumstances was it obtained? This writer will be the best able to inform us. "The period from 1815 to 1821 (7 years) inclusive, having been that of the most active service which has occurred in India, for many years past, has, therefore, been selected for these reports, as it was the best calculated to try the constitutions of the troops. During this time, the country was the seat of war, and the troops were obliged to make most harassing marches,

* Inserted in the *Journal of the Society of Arts,* May 12, 1876.

† *Journal of the Society of Arts,* April 28th, 1876.

and to perform the severest duties of an active warfare. They were exposed to epidemic cholera, which prevailed the greater part of this time; to the influence of seasons more than usually variable; to excessive heat, heavy monsoons, and sudden vicissitudes of weather. During this period, too, the army traversed a space of country from the 8th and 9th to the 25th degree of north latitude, and from the 75th to the 80th degree of east longitude." * That these rates were exceptional rates, and only observed during a period of war, it will not be difficult to show. Dr. Burke, Inspector-General, states that, in 1826, during the wars in Ava, Arrakan, and Upper India, the deaths in the Bengal army from *diseases alone*, exclusive of wounds, were 774; but, in the three subsequent years of peace, the average annual ratio was only 387, being just half. Dr. Burke adds, that, in 1830-31-32, the ratio of mortality with H.M.'s troops in Bengal was 38, 43, and 40 per 1,000 respectively, being an average of 40·33 per 1,000, although these years were not entirely years of peace or inactivity.† In 1836, the ratio, in the same army, was 37·60 per 1,000. In Ceylon, also, according to the statistics contained in the first Army Report, 1859, the annual ratio of the white troops, for the nine years, 1837-46, was 41·74 per 1,000. In 1859, it was 35·06, and yet, as Dr. Macnamara has remarked, prior to 1859–60 the British forces in Bengal (and the same remark will apply to the other Presidencies) were almost constantly engaged in active service. The difference between a state of peace and of war will be satisfactorily shown by a reference to the mortality of the European officers of the native army. In the "Madras Courier," October 21, 1816, the following particulars are given of "the mortality, which occurred

* "*Sketches of the most Prevalent Diseases of India,*" p. 227.

† *Edinb. Med. and Surg. Journal*, vol. 41, p. 386—1834.

in the space of three years, 1813-14-15 (a period of peace), in a class of the European society the most exposed to the climate," viz., the officers of the army. Strength, 1,366, deaths, 115; ratio per cent., 8·43, being an annual average of 28·06 per 1,000. But of 1,260 European officers in the Bengal army, the deaths, in the year 1820 —a time of war—were 74, being a ratio of 58·93 per 1,000.* With these facts before us, it is easy to account for the low rate of mortality, that has been observed of late in India, with a profound peace of fifteen years, more especially when other circumstances are taken into consideration. These are—(1.) The present short period of service. Formerly, the European troops of the East India Company, and frequently the royal troops, remained in India twenty-one years. Now, the regiments do not remain above six or seven years, while many of the men, whose period of service has expired, leave previously. The influence of this circumstance, in the prevention of disease, will be evident by a reference to the following Table, drawn up by Captain Henderson :—

Table showing the progressive increase of danger, with increasing years and residence, with British Troops in India.

Age.	Rate of Mortality.
From 20 to 22	2·24 per cent.
" 22 to 24	4·63 "
" 25 to 30	5·86 "
" 30 to 35	5·22 "
" 35 to 45	6·78 "

Captain Henderson adds, that "the experience of the Calcutta life insurance offices, wonderfully bears out the fact, shown in all the general tables, prepared from the honourable Company's different services, of the *regularly*

* Miles, quoted by Mr. Annesley.

progressive ratio of danger from increasing years and prolonged residence in India." This holds good from the age of twenty to sixty; "shortly after which period of life, the longevity of the surviving Anglo-Indians almost keeps pace with the Northampton and other tables."* (2.) Another circumstance is, the difference in the rate of invaliding now and formerly, caused by the present easy and short voyage between the two countries. Dr. Burke states, that the loss by invaliding of H.M.'s troops in Bengal, from 1826 to 1832 inclusive, was, on the average, 1·2 per cent., or 12 per 1,000—the highest, in 1826, being 4·7 per cent.; caused, principally, by wounds in the wars in Ava, Arrakan, &c. In 1827-28, on the termination of the war, when the same cause, we may presume, was partially in operation, the ratio, each year, was 1·3 per 1,000; in the next four years, it only amounted to ·30 per 1,000, or less than one for every 3,000 of the strength. But in 1861, the rate of invaliding was 31·68 per 1,000; and in 1868, in the midst of a profound peace, 67·7. If now we turn to the ratio of mortality for the above periods, we shall find, that it was 40, 28·70, and 21·71 per 1,000 respectively—a difference that may, in a great measure, be accounted for by the difference in the rate of invaliding.† (3.) The establishment of railroads will also account, to a certain extent, for the reduction in the present rate of mortality in India. Nothing, in fact, was more common, formerly, than for troops on march to

* Results of an Enquiry (by order of the Bengal Government) respecting the Law of Mortality for British India.—*Asiatic Transactions*, 1836.

† According to the Report of the Sanitary Commissioners with the Government of India, the rate of mortality with the women of the Bengal European army, in 1872, was 46·12 per 1,000. Unlike the men, they are not invalided and sent home when sick, but remain in India until the return of their husbands.

be attacked with fever and cholera, on encamping for the night in one of the uninhabited districts of this vast continent, and this, too, when no disease existed in the surrounding districts. (4.) Another cause to be taken into account is an improved method of treatment, particularly of dysentery. The old method—that by scruple doses of calomel—having been little better than murderous.

We can thus account for the reduction in the rate of mortality in India, irrespective of sanitary reform, which could not possibly have had any influence in the production of this effect. If no beneficial result has been observed in England after a trial of fifty years, the general rate of mortality being greater now than it was previously, it is not likely that a different effect will have been produced in India in a fourth part of the time.* Sanitary reform was inaugurated in India by Lord Lawrence, in 1864, the first Board of Health having been established, shortly before my arrival in Calcutta, in the autumn of that year; but no appreciable effect had been produced in 1871, the average ratio of mortality for the three years, 1861, 1862, and 1863, previous to the inauguration of sanitary reform, having been 24·85 per 1,000; and for the three years, 1869, 1870, and 1871, 23·84, a difference of only one per 1,000. This rate is only what had been obtained previously in India. According to the Report of Dr. Henderson, the ratio of mortality in Her Majesty's 48th Regiment, stationed at Billary, from December, 1829, to December, 1830, was 22·30 per 1,000.† There

* Dr. Macnamara, late Surgeon-Major, of the Bengal Medical Service, in his reply to Dr. Sutherland's letter, says: I do not know of a single cantonment in Bengal, (excluding the Presidency) in which an efficient system of drainage or water-supply has been introduced.—*Lancet*, Dec. 11th, 1875.

† *Madras Quarterly Medical Journal*, January, 1841, p. 121.

has been, it is true, a great reduction since, viz., 16·32 in 1873, and 13·50 in 1874; but then, if this reduction is to be referred to sanitary reform, we should expect to find that some, if not the same, effect had been observed with the native troops, who must also participate in the benefit to be derived from such measures: this, however, is not the case. Captain Henderson states, that during five years, 1830 to 1835, one man per annum, out of every 135, died in the Bengal native army, being a ratio of 7·40 per 1,000.* In 1836, the deaths in the same army, composed of 72,814 men, were 771, which gives a ratio of 10·10 per 1,000.* But, in 1873, the ratio of mortality, with the same troops, was 17·4 per 1,000. As regards the reduction in the rate of mortality in 1873 and 1874 with the British troops, this may be ascribed to the non-prevalence of cholera, there having been only twelve cases in 1874. It may, perhaps, be argued, that this extemption is due to sanitary measures; that, however, would be a very erroneous conclusion, for two reasons. In the first place, epidemics only prevail generally in particular years, and, in the next, because, if sanitary measures had exerted any influence in the prevention of this modern scourge, it ought, at the same time, to have lessened its malignancy; but the epidemic cholera is three times more malignant and fatal in India than it was formerly. In the Madras European army, the ratio of mortality, from cholera, in 1818, 1819, 1820, and 1821, was, calculated on the cases, 18 per cent. In the subsequent twenty years, the average was 33 per cent. Even in the fearful outbreak at Kurrachee, in 1846, the ratio, with the European troops, was only 58·70, and with the women and children, 61·67 per cent. But, in 1872, the ratio, with the British troops in Bengal, was 70·82, and, with the women and children, 71·85; in

* *Trans. of the Asiatic Society*, 1836.

Bombay, the rate, with the men, was 78·26, and, with the women and children, 90·90 per cent. In 1874, also, although there were only 12 cases, 11 proved fatal; being a ratio of mortality of 91·66 per cent.

Such are the reasons which induce me to infer, that sanitary reform has produced no beneficial result in India; and that the lower rate of mortality, lately observed in that country, with British troops, is to be referred to other and different causes—to those that have been now pointed out.

Similar, erroneous, conclusions are drawn respecting the effect of sanitary reform in England. Some of its advocates give an appalling picture of the ravages of the plague, and other diseases, during the last pestilential epoch; and then compare these results with those observed at the present time—which is merely the commencement of a new pestilential epoch—ignoring altogether the intermediate period, when the plague and other epidemics had entirely disappeared; and when all ordinary diseases gradually lessened in intensity and frequency to a most remarkable extent.* If, instead of the Bills of Mortality, we turn to the Tables of the Actuary, we shall find the same result. Mr. Griffith Davis stated, in 1843, that he had ascertained, upon indubitable authority, that a gradual diminution had taken place, in the mortality of the inhabitants of this country, for the preceding 100 years. Between 1720, and 1820, the mortality had decreased two-fifths. In Manchester, the diminution has been as follows:—

In 1757, there was one death in 25: or 40 per 1,000 of the population.

In 1770, one in 28 or 35.71 per 1,000.

In 1811, one in 74 or 13.51 per 1,000.

* See Table 5, in the First Part of this Work, p, 119.

Had the comparison been made with the 17th instead of the 18th century, the difference would have been still more striking. Independently of the diminution in the rate of mortality, the subsidence of disease, at this period, can be shown in another way—by a reference to the rate of survivance, at this and former periods.

Table A.—*Rate of Survivance at the undermentioned periods, and at different ages, in the City of Geneva.*

Years.	No. of those born, who reached 10 years of age.	No. of those over 10 years, who reached 40 years of age.
1560 to 1600	42 per cent.	43 per cent.
1601 to 1700	48 ,,	53 ,,
1701 to 1760	60 ,,	68 ,,
1761 to 1800	61 ,,	71 ,,
1801 to 1813	69 ,,	72 ,,
1814 to 1833	74 ,,	72 ,,

It is thus apparent, that the chances of life, of survivorship, had nearly doubled in the course of two centuries. It appeared, in fact, that a sanitary millennium had set in about the middle, and particularly towards the end, of the last century; a pleasing illusion, that was suddenly dissipated, in 1830, by the advent of the epidemic cholera, followed by fever and other diseases, which prevailed to a great and unusual extent—thus inaugurating the commencement of a new pestilential epoch. One fact is sufficient to prove this. It has been just stated, that the rate of mortality in Manchester, in 1811, was 13·51 per 1,000. But, during the 10 years—1851—60, the average death rate, in this town, was 31 per 1,000—more than double. So far from sanitary reform having prevented the return, mitigated the severity, or lessened the mortality, of any disease, it has been actually provocative of disease in many instances. This was the case at Croydon, Sandgate, the Golden Square district, and other localities.*

Another instance, which has been recorded since, may be mentioned here. A correspondent of the *Times*, (Jan. 17th, 1876), referring to the prevalence of disease in Edinburgh, remarks: "In one part of it (Edinburgh), congregated together, and inhabited by the lowest of the population, there are, according to the Corporation return for 1874, no less than 14,319 houses or dwellings—many under one roof, on the 'flat' system—in which there are no house connexions whatever with the street sewers, and, consequently, no water-closets. To this day, therefore, all the excrementitious and other refuse of the inhabitants is collected in pails or pans, and remains in their midst, generally in a partitioned-off corner of the living room, until the next day, when it is taken down to the streets and emptied into the Corporation carts. Drunken and vicious though the population be, herded together like sheep, and with the filth collected and kept for 24 hours in their very midst, it is a remarkable fact, that typhoid fever and diphtheria, the two diseases that, in the words of Dr. Simon, are the direct emanations from the filthiest of all filth, are simply unknown in these wretched hovels. If however, we turn to the fashionable or new town, we find the houses provided with all the modern conveniences, and communicating with drains which the natural contour of the city ought to render most effective, but with here and there a cesspool, and we find that typhoid fever and diphtheria are never absent. Further, the Corporation, as time and opportunity permit, insist upon the introduction of water-closets in workmen's houses, and with reference to these, the medical officer reports, that typhoid has

* For the particulars of these outbreaks, vide *Causation and Prevention of Disease.*

invariably made its appearance within six or nine months, and that any fever breaking out has shown itself to be of a *malignant type*, never before known in those dwellings."

That sanitary measures have failed to produce any beneficial effect, may be inferred from the fact, that the majority of the profession, in England, have adopted the doctrine of contagion of late years. But the founders of sanitary reform rejected this doctrine altogether. Nevertheless, one of the strongest advocates of this so-called reform is now a rank contagionist. In 1854, Mr. Simon thus wrote: "For the permanent avoidance of epidemic diseases, cleanliness (*i.e.* the removal of decomposing matter on the surface) is the sole remedy."* Now, however, Mr. Simon concludes, that "human contagion is the one active power in the international spread of cholera."† Hence, in order to prevent visitations of this disease, the coasts are to be watched, ships are to be placed in quarantine, the sick are to be isolated, and the healthy removed to other localities; while the corpse is to be buried "with the earliest possible dispatch"‡—even at the risk of burying a certain number of patients alive, as was actually the case during the visitation of cholera in the West Indies. We were also told, by the same authority, at the above period, that "the general liability of London to suffer the epidemic visitation (of cholera) will cease, whenever an efficient and inodorous system of drainage is established." But in 1874, among the dangers to be guarded against, during the prevalence of cholera, are: "outflow, leakage, and filtration from sewers, drains, etc."§ This change of opinion has arisen, in consequence

* *Report to The Common Council of the City of London.*

† *The Lancet*, May 12th, 1877. ‡ *Ninth Report to the Privy Council.*

§ Memorandum of Precautions to be taken against the Infection of Cholera, in Mr. Simon's Report for 1874.

of Mr. Simon having adopted the theory of the late Dr. Snow, who inferred, that "the *materies morbi* of cholera is something which passes from the mucous membrane of the alimentary canal of one person to that of another; this it can only do by being swallowed." This is effected principally, according to this writer, in consequence of the contagious matter escaping from cesspools and sewers, and finding its way into the drinking water. This notion has been since taken up by Dr. Budd, and applied to typhoid fever. Referring to the influence of drains and sewers, in the spread of typhoid fever, Dr. Budd remarks: "They propagate it solely, in consequence of being the channels for the diffusion of this poison."* By poison, Dr. Budd means contagious poison, for he states in another place; "The living human body is the soil in which this specific poison breeds and multiplies." These conclusions have also been adopted by Mr. Simon, although both Dr. Snow and Dr. Budd repudiate his *filth*-theory, and ridicule the idea of putrid emanations being the cause either of cholera or of fever. It thus appears, that what was before held out as a panacea for all the ills to which flesh is heir, is now regarded, by Mr. Simon, as a source of danger—the cause of death rather than the cause of health. Can inconsistency go farther than this? Really, the drains and the sewers may say, as certain persons have said of themselves, preserve us from our friends, we will defend ourselves from our enemies.

The above, however, is not the only source of danger. Dr. Budd infers, that the contagious virus is spread by tainted hands, linen, bedding, clothes, etc., and by emanations borne on the air—conclusions that have been adopted by Mr. Simon, as we shall find by the following

* *On Typhoid fever.*

quotation. "The facts which Dr. Budd adduces, from his own experience, and from that of others, are, in my opinion, sufficient to prove, that the *contagion* of typhoid fever is importable by persons who have it."* As, also, typhus, measles, scarlet fever, and small-pox, are all considered to be purely contagious diseases, there is nothing left for sanitary reform to effect, as Mr. Simon has himself indirectly, and, perhaps, unconsciously avowed. To the question put by the Chairman of the Vaccination Committee; "Do you or do you not consider, that sanitary improvements, both as regards dwellings, and as regards greater cleanliness of the person, might, in themselves, very much diminish the prevalence of small-pox?" Mr. Simon replied; "I have no evidence that it can do so."!† And yet, in 1854, the witness affirmed, as we have already seen, that "for the avoidance of epidemic diseases (and small-pox is a true epidemic) *cleanliness is the sole remedy.*" As the same arguments will apply to every other contagious disease, and as there is no general disease left, unless it be ague, that is not now considered to be infectious, there is an end of the question. The removal of filth on the surface, cannot prevent the infection spreading from one person to another: while the only use of drains and sewers, according to this doctrine, will be to diffuse the contagious emanations in the air and in the water, for the express object of poisoning H.M.'s subjects.

But the most extraordinary part of the affair remains to be told. Although adopting the doctrine of contagion, Mr. Simon continued to ascribe the origin of typhoid fever to the products of decomposing matter, diffused either in the air, or in the water used by man as drink.

* *Report to the Privy Council*, 1861.

† *Report of the Vaccination Committee*, p. 165.

Referring to the outbreak of typhoid fever at Tirling, in 1867, Mr. Simon remarked: "The cause of all this terrible sickness and mortality was, of course, evident to your Lordship's Inspector at *a glance!* It was the merest question of *filth*"!* Not only this, but Mr. Simon, in the same year, had the folly and rashness to propose, that Public Bodies should be made responsible for outbreaks of typhoid fever, like the Railroad Companies for accidents. He remarked—"It seems to me, that the time has now come, when, not only as regards Water Companies, but also as regards *local sanitary authorities*, certain sorts of malfeasance should involve an obvious and unquestionable liability *to pay pecuniary damages* to persons whom the malfeasance has injured." † Strange as it must appear, six years before these recommendations were made, Mr. Simon had adopted, as previously shown, the theory of Dr. Budd—a theory that ascribes both the origin and the propagation of typhoid fever solely to infection. "Typhoid fever," remarks Dr. Budd, "is not only self-propagating, but it *originates in no other way*," (*loc. cit.* p. 164). If so, the Water Companies cannot be answerable for the propagation of typhoid fever: they cannot prevent the introduction of infectious matter into the water: it is the doctors and the nurses who will be responsible for this, if anybody is to be. All the Water Companies can do is to prevent the entrance of organic and decomposing matter into the water. But this matter can have nothing to do with the production of typhoid fever, if it arises from infection, as Mr. Simon infers. Not only would the prosecution of these parties have been a crying shame, and an injustice, but any measures that had been adopted, for cleansing the surface or purifying the water, would have been as use-

* *Report to the Privy Council*, 1867, p. 28. † Idem.

less as the attempt to wash the blackamoor white: and for the simple reason, that typhoid fever is *not* produced either by the products of putrefaction, or by a contagious virus.

If, however, sanitary measures be useless, their adoption is not only a mockery, but it occasions an enormous pecuniary loss to the country annually. We expended, in 1874, upwards of eight millions in carrying out sanitary measures,—a sum that may be taken as the average yearly expenditure during the last quarter of a century. Hence the great addition to the rates, which have increased, during the above period, by ten millions or more annually: while even this sum has been found to be insufficient, the local authorities having incurred a debt of £84,000,000. This is independent of the money expended by private persons —the owners of houses—who are compelled to drain into the main sewer at their own expense. If we were to add the two amounts together, we should probably find, that hundreds of millions have been expended, during the last forty years, in sanitary works.

The money thus expended has not only been thrown away, as much so as if it had been cast into the sea, but it has occasioned an indirect loss, amounting to as much more, by preventing the utilisation of the excreta of man. When mixed with a large quantity of water, as is necessarily the case with the system of water-closets and house drains, its effect, excepting on grass lands, is very insignificant. Mr. Campbell, of Rugby, states, that he had employed the sewage of that town, to the extent of 45,000 gallons (204 tons) per acre; but he came to the conclusion, that the application of sewage, so largely diluted with water, produced very little fertilizing effect. This we can readily understand, for as nearly all the fertilizing ingredients are soluble in water, the greater

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part would be carried away into the adjoining river or into the lower strata of the earth; as sometimes occurs after heavy falls of rain. "The reason why, in certain years, the influence of the best and most plentiful manuring is scarcely perceptible," observes Liebig, "is that, during the moist and rainy springs and summers, the phosphates, and other salts with alkaline bases, as also the soluble ammoniacal salts, are *entirely* or *partly* removed." This effect would be increased on all those lands in which sub-soil drainage has been carried out. On the other hand, no system has yet been discovered, or is likely to be, of separating this matter from the fluid in which it is contained, without destroying, to a greater or less extent, its fertilizing properties. And yet, the emanations arising from the excreta of man have no injurious effect, excepting on the olfactory nerves, and in the imagination of certain theorists. On the contrary, they act rather as a preventive of disease. Does any one doubt the fact? If so, let him peruse the evidence that has been advanced by me on previous occasions, and he will then, perhaps, be as convinced as myself of the truth of this conclusion.* Not only may we use this matter without any fear or risk, but, we may also collect and preserve it, in its solid state, until required for use; without which it would be impossible to apply it to corn lands,—there where it is most wanted. The advantages resulting from the application of this matter to the land, in its undiluted state, would be immense.†

* *Causation and Prevention of Disease.* And the First Part of this work; chapter, Modern Theories.

† This subject has been discussed by me on two previous occasions; in the Appendix to *The Causation and Prevention of Disease*, and in a Pamphlet, *The Utilisation of the Sewage of Towns.* Referring to the Main Drainage Scheme, which had not then been carried out, I remarked, in the former work: "It

In the first place, there would be a larger yield, human manure being more valuable than any other. This will be evident by a reference to the following Table :—

TABLE B.—*Showing the Result of Experiments with different Manures.**

	Quantity produced in proportion to seed.
No manure	3 times.
Herbage, grass, &c.	5 „
Cow dung	7 „
Pigeon's dung†	9 „
Human urine	12 „
Night soil	14 „

In the next place, the corn grown upon such land would be more nourishing. Irrespective of mineral matter, the two principal substances required by man, as food, are carbon and nitrogen. The former can be, and is usually obtained, and in much larger quantities, from other and cheaper articles; but the latter, although present in every

has been gravely proposed by a public Board, and the proposal has received the sanction of the Legislature, to throw this valuable matter (the excreta of the population) into the sea; and this act of Vandalism is about to be committed in the middle of the nineteenth century, in what is termed an enlightened and scientific age, without so much as a particle of *direct* evidence having been produced to demonstrate its injurious qualities. Were the authorities in California or in Australia to order the produce of the gold-mines to be thrown into the sea, the act would not be more insane or less uncalled for. I trust, however, it is not too late to prevent the disgrace that would inevitably attach to the committal of so egregious a blunder; and at the same time to save the nation the loss that must accrue, if that plan be carried out; for it would then be difficult, if not impossible, to apply the contents of the sewers to agricultural purposes."

* By Professors Hemstadt and Schübler.

† This would be about the return for guano.

kind of vegetable, exists there in so small a quantity, that an addition from other sources is required; and as this can be obtained in corn, we have an explanation of its universal use. But the quantity of nitrogen, or of gluten, varies greatly, according to the locality in which it is grown, or, according to the nature of the soil. This is shown in the annexed Table.

TABLE C.—*Quantity of Gluten contained in different varieties of Wheat.*

Varieties.	Authorities.	Per Cent.
French Wheat ...	Prout	13·5
Ditto Alsace ...	Boussingault ...	17·3
Barbary Wheat ...	Davey	19
Sicilian ditto ...	„	21
English ditto ...	„	24
French ditto ... (Jardin des Plantes)	Boussingault ...	33

That this variation, in the quantity of gluten, is to be ascribed to the greater or less quantity of ammonia furnished by the soil, or by the manures applied to it, will be apparent by a reference to the next Table.

TABLE D.—*Quantity of Gluten in Wheat, grown on Soils to which the following manures had been added.*

Manure.	Gluten.	Starch.	Bran.	Total.
Human Urine ...	35·1	39·3	25·6	100 parts.
Bullock's Blood...	34·2	41·3	25·5	100 „
Night Soil ...	33·1	41·4	25·5	100 „
Horse Dung ...	13·7	61·6	24·7	100 „
Cow Dung ...	11·95	62·34	25·71	100 „

The urine of animals contains a large quantity of nitrogen, but the proportion is very much less than in that of man, as exhibited in the annexed Table.

TABLE E.—*Quantity of Urea* contained in* 1,000 *parts of Urine.*

Man	32·91	† In herbivorous animals, there
The Ox† ...	19·76	is, in addition, hippuric acid,
Horse	12·44	which, during the process of
Pig	4·9	putrefaction, is converted into
Goat...	3·7	benzoic acid and ammonia.

This is what we should have expected, *à priori*, for the food of animals not only differs from that of man, but from that of each other—carnivorous animals making use of a more highly nitrogenized diet than herbivorous ones. It is for this reason that guano, which is composed of the *excreta* of wild sea-fowl, living on fish, has been so extensively employed of late, and since its discovery, as a dressing to wheat and other corn crops. But this manure is not only an expensive one, its supply also is limited. Referring to the quantity of guano and bones imported into England, Baron Liebig observes: "Yet all this mass of manure is not worth mentioning, when compared to the arable surface of Great Britain, and is but a drop, when compared to the sea of human excrement carried by the rivers to the ocean." † The deficiency can now only be made up with animal manure, which is not half as productive as human manure. The supply of this, also, is limited: while, if we add it to the arable land, we take it away from the pasture land, where it is equally required. At present, the urine of animals is only applied to corn land, when it has been planted with artificial grasses or

* Nitrogen exists in the urine, principally, in the form of Urea; a compound of carbon, hydrogen, oxygen, and nitrogen; the latter in the proportion of 46·67 per cent.

† *Modern Agriculture*, page 232.

roots, and when sheep or oxen have been fed with them, on the land. It is to be remembered, however, that by this system, or the rotation of crops, the animals pastured on this land can only replace the quantity of nitrogen they have taken from the soil, in the form of food; there will be, therefore, no actual gain, or increase in the quantity of nitrogen previously existing in the soil. The only difference is, that the turnips and the artificial grasses do not abstract as much nitrogen from the soil as the corn crops: so that a certain quantity may be stored up for the future, if there be an excess in the land previously, but not otherwise. If, however, all the elements taken away by man, in the form of food, were restored to the soil, the necessity for the rotation of crops would be avoided, as the land might be made to bear corn crops continuously. This is the case in China, for "the Chinese cultivators," as Liebig has remarked, "though they fatten no animals, and make no manure on their farms, have, nevertheless, successfully fed, for thousands of years, a population more crowded than any in Europe; maintaining the fertility of the land by simply observing the law of compensation, in the replacement of nutritive substances, which the crops have carried away from the soil."

In Belgium, also, the excreta are carefully preserved, and applied to the land: the fertility of which is well known. It is the same at Milan and Florence. In the latter city, two or three cesspools are emptied every night; and long carts, like brewers' drays, filled with casks, may be seen in the evening, outside the city gates, waiting the appointed time to enter; and carry away, what is there considered to be, the valuable and precious load the land in the immediate neighbourhood being poor and arid; and would be, without this manure, all but unproductive. And yet, notwithstanding this daily operation, and the preservation of this undiluted matter in cesspools, Florence is not only the healthiest city in Italy, but would compare favourably with any other city in Europe, in point of salubrity.

That the excreta of man contain all the elements that have been taken away by him, in the form of food, is satisfactorily shown in a Table drawn up by Dr. Angus Smith, and now added.

TABLE F.—*Quantity of Nitrogen, and other ingredients, taken from the Soil, and furnished by the Excreta of Man.*

Elements removed by a four course system, from 100 acres.		Ditto, consumed by 100 adults.	Ditto, supplied by the Excretions.
	lbs.	lbs.	lbs.
Nitrogen	2,681*	2,317	2,312†
Lime and magnesia ...	948	3,158	3,158
Phosphoric acid ...	1,549	1,713	1,713
Potass and soda ...	780	827	827
Silica	450	166	166
Metallic oxides ...	8	6	6
Sulphur and chlorine...	21	87	87

* Per acre, 26·81. † Per man, 23·12 yearly.

Not only could we keep the present corn lands in perpetual fertility, but we might, at the same time, double the produce; as, making every allowance for the quantity of guano used, it is probable, that the arable land in Great Britain does not receive above half the requisite quantity of nitrogen and other elements. This conclusion would appear to be confirmed by the result of an experiment of the Earl of Essex, who obtained 53 bushels of wheat, and five loads of straw, from an acre of land irrigated with sewage water—being nearly double that of the average return; viz., 28 bushels.* If the same return were

* This return was only obtained by the employment of a large quantity of sewage. His Lordship stated, at a Meeting of the Society of Arts (March 19, 1862), that he made a great mistake in supposing, that the sewage of the town of Watford, with 4,000 inhabitants, would be sufficient to irrigate 200 acres; for he had since found, that the whole sewage of the town would not be

obtained from all the corn land in these islands, there would be—irrespective of losses from bad seasons—sufficient for the present home consumption, as can be readily shown. The average produce of wheat lands, in this country, may be set down at 12 million quarters. In 1874, it was 15 million quarters, being above the average; and 9 millions in 1875, being as much below—the variation having been caused by a difference in the weather. Now it has been calculated by Mr. Lawes—a good authority on the subject—that the present consumption of wheat in the United Kingdom is 24 million quarters, exactly double the home produce. If, therefore, this produce were doubled, the importation of foreign corn would be rendered unnecessary, under ordinary circumstances.

That such might be the case, would appear certain from what has gone before; as, if 53 bushels of wheat, per acre, can be obtained by sewage water, an equal, if not larger, return might be expected from the same matter, in its undiluted state. Even this return, viz. 53 bushels, would, for the quantity of land now devoted to wheat culture—three and a half million acres—produce, on the above hypothesis, 23,187,500 quarters, within a trifle of the quantity required, for our present consumption. But much more land might be brought into cultivation, if there were an adequate supply of manure, for the quantity of corn land is not in proportion to the area contained within the United Kingdom. In 1851, and there has not been much variation since then, the pro-

sufficient for more than sixty acres. This would be at the rate of sixty-six persons to an acre! In other instances, the sewage is applied in still larger quantities. The Craigentinny meadows, comprising 325 acres, receive the sewage of about one-half of the City of Edinburgh, with a population of above 80,000. This number would give 246 persons to the acre. But the excreta of one man is sufficient, as is evident from the preceding Table, if properly applied, to fertilize an acre of corn or other land.

portion of cultivated and uncultivated land, as calculated by different writers, was as follows :—

Table F.—*Showing the Quantity of Cultivated and Uncultivated Land in Great Britain* (1851).

	Corn.	Roots, Clover, &c.	Pasture.	Uncultivated	Total.
	Acres.	Acres.	Acres.	Acres.	Acres.
England	7,972,500	5,327,500	17,000,000	6,507.915	37,324,915
Scotland	1,430,621	1,584,951	11,031,890	6,000,000	20,047,462
Ireland	2,831,029	1,831,963	11,145,279	5,000,000	20,808,271
Total	12,234,150	8,744,414	39,177,169	18,024,915	78,180,648

Of the 18 million acres of uncultivated land, a sixth part might, probably, be brought into cultivation, if regularly supplied with human manure. Even corn would grow there as well as, if not better than, other crops, for as it would then receive all the elements necessary for its growth and nourishment, with the exception of silica, which is to be found in some of the poorest soils, all that such plants could require would be a certain amount of earth to fix their roots in, and room to grow afterwards. Instead of a deficiency, there might then be a surplus quantity of wheat grown in these islands.

The same arguments will apply to all other crops, as there would not only be sufficient manure, from this source, for all the corn land in Great Britain, but for that devoted to the cultivation of roots and artificial grasses— the produce of which, as experience proves, might be doubled or trebled. The same quantity of pasture land would not then be required, as now, not only because a greater number of animals could be fed on this artificial food, but also because the manure from these animals, instead of being applied to arable land, might then be diverted to pasture land. As the grass grown on such land would be more nourishing, it could support a greater number of animals, more especially if, as might be, human excreta were added at the same time; the quantity, with our present population, being more than sufficient for all the arable land. There would, in fact, be sufficient manure for 40 million acres, out of the 59 or 60 millions now in cultivation. At present, the only nitrogen, which is added to pasture land, is that derived from the animals fed on it: but that which is taken away by man, in the form of beef and mutton, as, also, that abstracted by hay, is never returned. Hence the necessity of restoring even to pasture land, what has been removed indirectly by man; and hence the large increase in the crops, invariably observed, whenever human excreta have been applied to such land. At Edinburgh, the grass on the meadows, irrigated with sewage manure, is sold by auction, and realises from 30*l*. to 40*l*. per acre, every year. A large quantity of sewage, however, as before stated, is necessary to produce this effect; it would be different with the solid or slightly diluted excreta. As the land, thus highly manured, would feed a larger number of animals, the necessity for the importation of so much live stock would thus be avoided. What additional number of cattle might be so fed, it is impossible to say; but my own belief is, that if all the surplus excreta of the inhabitants of these islands—that not required for corn land—were applied to root crops, the artificial grasses, and pasture land, sufficient animals might be reared to prevent the necessity for the importation of live stock, or of sheep and bullocks—about half our supply, at present, being derived from abroad.

Such are the results that might be expected, looking at the subject in an agricultural point of view only, by the application of the excreta of the population of these islands to the land. What the gain would be, in a financial point of view, may be ascertained by calculating the amount annually paid for the food imported into England. We can also ascertain the value in another way; directly instead of indirectly: or, by comparing the quantity of nitrogen in human excreta with that in some other substance—as guano,—the value of which is known. It has been found, that 3 cwt. of guano which contains about 8 per cent. of nitrogen, is sufficient, as a dressing, for an acre of corn land. In this quantity of guano, there would be 27lbs. of nitrogen; exactly the amount that is found in the urine that is passed by each person in the course of the year, viz. 912lbs. on the average. As such, the liquid excretum of each person would be alone sufficient to fertilize an acre of corn or other land: and a population of three millions the same number of acres. These facts will be more clearly perceived by a reference to the following Table:—

TABLE G.—*Showing the Number of Acres that the undermentioned Individuals would fertilize annually, Guano being the standard of comparison.*

Supply.	Quantity.	Proportion of Nitrogen.	Number of Acres.
Guano	3 cwt.	27 lbs.	1
Urine, for 1 individual ...	912 lbs.	27·36 lbs.	„
Guano	15,000 tons	1,205 tons	100,000
Urine, for 100,000 persons	40,714 „	1,221 „	„
Guano	450,000 „	36,150 „	3,000,000
Urine, for 3,000,000 persons	1,221,420 „	36,630 „	„

As a population of 40 millions would fertilize 40 million acres; and as, if guano were employed instead, it would require 6 million tons, this quantity, at 13*l*. a ton, would amount to 78,000,000*l*. This sum, therefore, represents the annual value of the liquid manure for the above number of people. But the solid manure is worth nearly as much as the liquid, for it produces nearly the same amount of gluten, as shown in Table D (page xx). We may, therefore, calculate the total value of the excreta of a population of 40 millions at 150,000,000*l*. annually, were it regularly applied to the soil. This would not, and could not, be the case under ordinary circumstances: but if two-thirds were employed, it would amount to 100,000,000*l*. This is about the sum we pay annually for foreign produce; and as the two amounts coincide or nearly so, we are enabled to calculate, within a trifle, what the annual loss now is, and what the gain would be—if the preceding calculations hold good, or be allowed.

This is the aspect of the question at the present moment; but it will become much worse hereafter, should we continue to throw this valuable matter into the sea, the same as before. As the supply of guano is limited, even were the agriculturists willing or able to pay for it; and as there is no other known substitute, the land must gradually become less and less fertile; and the produce be less and less every year, as experience proves. Baron Liebig, speaking of the tracts of land in America on which the early colonists settled, but to which they failed to add any manure, remarks:—" We all know what has become of these fields. In less than two generations, though originally so teeming with fertility, they were turned into deserts, and, in many districts, brought to a state of such absolute exhaustion, that even now, after having lain fallow more than 100 years, they will not yield a remunerative crop of a cereal plant."* That the land in England is becoming exhausted, may be inferred from the great increase in our food imports during the last seven years—a result that cannot be accounted for by bad harvests, murrains, or the increase of population alone. Thus, in 1870, we only paid six millions for the beef, mutton, bacon, cheese and butter, imported into this country: last year, (1878,) the amount was forty millions. It has, in fact, been stated, by a competent authority, that it would take 20,000,000*l*. to put the land into the same state it was *seven* years since. Should this continue, the present arable land in Great Britain will become less productive, year by year, and must cease, sooner or later, to bear a remunerative crop. It will have to be turned into pasture land, or, else, have to lie fallow for a time, if not altogether. Under these circumstances, it is not surprising, that the present condition of the British farmer is gloomy in the extreme. Not only are his garners poorly filled, but the price he has of late received for his crops has been so low, that his profits have become almost infinitesimal. Hence the numerous failures, of late years, among this class of persons. The *Times*, in its City Article (June 14, 1879), published somes figures from Mr. Richard Seyd, by which it appears that, in 1870, there were 270 failures; in 1875, 354; in 1876, 480; in 1877, 477; in 1878, 815; and, in the first half of 1879, no fewer than 614. As a consequence, the fall in the value of rents, lately, is enormous. As an illustration, the *Dundee Advertiser* states:—"The farm of Mains of Errol has just been let for nineteen years to Mr. James Kidd, at about 400*l*. below the old rent, besides a large sum expended on improvements free of interest. This is said to be one of the best farms in Perth-

* *Modern Agriculture*, p. 243.

shire, and is in high condition. The reduction in rent will be fully 40 per cent."*

In the mean time, as the corn grown on such land will be deficient in gluten, and as the animals fed on its produce, will be wanting in flesh, the people living on this food cannot be properly nourished: they will lose strength and become deteriorated.† To this cause I would refer the evident deterioration of Englishmen in the present day, as shown by the number of recruits constantly rejected. Sergeant Farrell, recruiting sergeant, stated to Dr. Playfair, that where he could get eighteen recruits formerly in Lancashire, he can only obtain *one* now, and that one is frequently rejected. At the head recruiting office in Lancashire, the total number of recruits sent up between January 1 and October 31, 1843, chiefly from Lancashire, Cheshire, and parts of Shropshire, Derby, North Wales, and Staffordshire, was 1,560 Of these, 876 were approved and 684 rejected. In Liverpool, during the same period, 930 presented themselves for examination, and 439, or 47 per cent., were rejected.‡ But, whatever conclusion we may draw on the subject of this deterioration, one thing, at least, is certain: if the corn crops do not contain the proper proportion of gluten, they will be deficient in nourishment; and those who feed on them will be wanting in *physique*, in muscle, in strength

* *Public Opinion*, May 10, 1879.

† The system adopted at the Smithfield, and other cattle shows, is an entirely erroneous one; the prizes being awarded to those animals that have the greatest amount of *fat*. But we do not eat meat for the sake of the fat, which is merely a hydro-carbon, for the carbon can be obtained from other and cheaper articles. It is the nitrogen of the flesh, which renders meat so nourishing: the prizes, therefore, should be given to those animals that have the largest proportion of lean, and the least quantity of fat.

‡ *Statistical Journal*, March, 1861.

and in energy. Liebig has, in fact, gone so far as to ascribe the downfall of empires to this circumstance alone —the exhaustion of the soil, and the non-renewal of its fertilizing properties by manures, containing the requisite proportion of nitrogen. Although this conclusion of the celebrated German chemist may be, and probably is, too sweeping a one, there can be no doubt that a nation, living upon articles not sufficiently azotized, will be wanting in physical energy. We observe this with the Hindoos, who subsist principally upon rice—the least nitrogenized of the cereal crops. We also find, that the descendants of those colonists who settle on new lands, or virgin soils, become a stronger and more athletic race than their progenitors. This has been observed in North America, notwithstanding that the climate there is much more unhealthy than in England. Hence the necessity of returning to the land the nitrogen taken from it.

There is another reason for this course. We are now living in an epidemic period, when murrains and disease in the vegetable creation are sure to occur, and to return more or less frequently. These results have been invariably observed at all epidemic periods, and, more particularly, during the last pestilential epoch, as will be shown hereafter. They have also occurred, since the commencement of the present pestilential epoch, to an alarming extent in the East—in China, India, Persia, Asia Minor and Africa —while we have had one visitation in Ireland from the failure of the potato crop, which then formed the staple article of food of the inhabitants. Although the same sad results were not witnessed in England,—this root not being so exclusively used—the crop was almost entirely destroyed: while there has been no year since, in which potatoes have not been affected, to a greater or less extent. In some years, the ravages of the disease have been nearly as great as on the first visitation. This was the case in 1872. "There can be little doubt," says one writer, "that the loss from the potato blight, in 1872, falls little short of the loss in Ireland in 1846: but it is not likely there will be any application to Parliament, as there was in 1846, for a grant of several millions to support the destitute. What will be the position of farmers in the greater part of England, and over almost the entire arable area of Scotland, when the rent due for crop 1872 fails to be paid, it is not easy to answer." (*The Farmer*, January, 1873.) Should these periodical visitations continue, as we have a right to expect, potatoes will gradually become less and less cultivated, until their cultivation ceases altogether, except to a slight extent and on particular soils. More corn, therefore, will be required as food, and the land not devoted to potatoes, must be planted with wheat, or other corn crops. If so, a larger quantity of guano or some other substitute will be necessary to make the crop remunerative. Although, for reasons that will subsequently appear, potatoes are more liable to disease than corn crops, the latter have not entirely escaped in Europe; and may be more severely and more generally affected hereafter, either from disease or from the vicissitudes of the seasons—great atmospherical vicissitudes being always observed at epidemic periods. This was observed in 1870, the dry summer of which, it was computed by good agricultural authorities, made a difference to this country of fifty millions. The opposite state, or the absence of the sun's rays, is no less injurious. As Mr. Scott, the agricultural writer, has remarked: "To the great deficiency of solar heat in July (1875), equal to 3°, I mainly attribute the inferiority of this year's crop; and, as indicating the natural influence of the elements upon the crops, and the nature of the seasons, I would adduce the result of Mr. Lawes' experiments on land, on which wheat is cultivated in succession without the aid of extraneous manure, and of which the following are the results :

1867	produce	$8\frac{7}{8}$	bushels per acre ; a bad wheat year.
1868	,,	$16\frac{5}{8}$	bushels per acre; the greatest wheat crop of the century.
1874	,,	$11\frac{1}{2}$	bushels per acre; over an average crop.
1875	,,	$8\frac{5}{8}$	bushels per acre; 25 per cent. under an average crop."

As the above variations can only be ascribed to external, or atmospherical causes, we can understand, why there should have been so great a variation in the produce of 1874 and of 1875. It was as follows, according to the above authority. Beginning with the wheat crop of 1874, the account stands thus :—

	Quarters.
3,821,655 acres, at 32 bushels per acre (an estimate generally agreed on)	15,287,000
1875 Crop.	
3,514,088 acres at 22 bushels an acre (my estimate on the 25th of August last, but now believed to be 2 bushels an acre above the average yield of the crop) ...	9,664,000

The writer adds, that "the crop of last year (1874) was 30 per cent. under the great crop of 1868, but still 25 per cent. above that of the present year," * 1875. Hence, another reason for a greater breadth of corn land, or, else, for a more abundant supply, by manure ; more especially as those countries from which we draw our chief supplies are as likely to be affected, if not more so, by these causes than we are.

* Letter inserted in the *Mark Lane Express*, November, 1875.

Independently of the preceding, there is another aspect to the question: one that affects, not the finances only, but, possibly, the future destiny of this country. I allude to the great difference between our imports and exports at the present time. In 1878, our debtor and creditor account, with foreigners, stood thus:—

		£
Imports	... ...	394,419,632
Exports	... ...	198,893,665
	Difference ...	195,526,567

Or, equal to £11 15s. 10d. per head, for the former, and £5 13s. 11d. for the latter.

There is a Spanish proverb which says: "If a man sells kids, and does not keep goats, whence do they come?" And we might say, if the nation spends, annually, 200 millions more than it receives, whence does the money come? As we have no gold mines, and as we receive no income from our Colonies, the money must come out of capital. We hear a great deal about the extension of trade and commerce since the introduction of Free Trade;* and so did the shareholders of the Glasgow Bank of the great increase in their business; but the outlay of the money, without an adequate return, ended in bankruptcy. And so it will be with the nation, sooner or later, unless some means be devised of arresting this large, and continually increasing, outflow of gold. What these means should be, it will be for legislators to determine. As, however, about one half of our imports are for food, suggestions have been already made for the lessening or

* By Free Trade, I do not allude to the free importation of food, for that is a necessity, with our present limited resources; but, to the free introduction of such manufactured articles as can be procured at home, and which, therefore, is *not* a necessity.

preventing of this part of the expenditure in future. As regards the other part, or the expenditure for manufactured and other articles, I must leave it to the Political Economists to suggest a remedy. I would merely call their attention to the following facts. In *Tinsley's Magazine* for March, 1879, Mr. J. Hatton, in an article, entitled, "England's Commercial Decline," calls attention to the pregnant fact, that the last return of *exports* from the United States, under a system of Protection, is the largest in her history; while the return of *imports*, under a system of Free Trade, is the largest in ours. *Verbum sat!*

There are other and minor evils attendant on the present sanitary system, and on the formation of drains and water-closets. At first, the local authorities were obliged to abolish cesspools, and to establish house drains; but, as they did not know what to do with the contents, they naturally drained into the nearest river. Finding that what would have been food to man, is poison to fishes; and that the water in all our rivers has become more and more polluted; the throwing of the contents of the house drains into a river is now prohibited. In consequence, actions are being brought against some of the local authorities for doing that, which they were compelled, by law, to do before. Thus, the Richmond Vestry, some years since, discharged the contents of the sewers into the Thames, and incurred a debt of £30,000, in order to carry out the plan of drainage recommended by the Metropolitan Sewers Commission. Lately, a penalty of £100 a day was imposed on the same authorities, as long as the sewage passed into the river; although no plan for diverting it was proposed or recommended. The Local Government Board simply ordered the mouth of the sewer to be stopped; and thus converted Richmond into one great cesspool. But it is not easy or even possible, in some cases, to dispose of the sewage, on account of the large quantity of water, which cannot be thrown upon the land, even on grass lands, daily, and at all seasons of the year, except by converting them into unproductive swamps. In some instances, the result has been merely the removal of a nuisance from one locality to another. This has been the case with the Metropolitan Main (mad ?) Drainage Scheme. As the Editor of the *Daily Telegraph* has lately remarked: "It is melancholy to be obliged to confess that, after some twenty or thirty years of enthusiasm for sanitary reform, and an expenditure of millions of money to save the Thames from pollution, we should find ourselves almost exactly where we were, when the agitation for the purification of the river was commenced. The state of the Thames, at any time below half-tide, is simply abominable. At low water, it is nothing less in many portions than a slow-moving volume of refluent mud. As for the state of the foreshores after ebb, the foul deposit—it would be a mistake to call it ordinary river mud—which overlies the clean, gravelly, bed of the stream, is growing greasier and thicker every year. The river banks at Woolwich, Barking, Erith, Purfleet, and the vicinity below the Main Drainage outfalls, tell a tale which no statistics can refute, and no explanations explain away. The river for miles of its course is simply a solution of oleaginous mud, the contributions of sewage which, in spite of positive assertions to the contrary, is not, and cannot, under present arrangements, be carried out to sea. . . . Such, then, is the state of the Thames at the present moment, after fourteen years of the Metropolitan Main Drainage scheme; so that, although the discharge from the outfall occurs, in part, outside the metropolitan boundary, the metropolis has not got quit of its sewage. In fact, as matters now stand, the Main Drainage system has reproduced in mid-Thames, in an aggravated form, the nuisance which became so unbearable in the upper part of the river. Formerly, the London sewers discharged their contents into the river at low water, first to be carried by the rising tide up the stream, then to be brought to London by the following ebb tide, there to mix with each day's fresh supply, the progress of many days' accumulation towards the sea being almost imperceptible. Will it be believed, that this exactly describes the existing state of things in the mid-course of the Thames to-day, after an interval of fourteen or fifteen years? The only difference now is that the nuisance, which was formerly brought down to London by the ebb tide, is now carried up to London by the flood. . . . So flagrant a failure of our sewage arrangements is not to be remedied by any half-measures. It is now plain, that nothing short of sacrificing the present outfall system of drainage will meet the case. The compromise with sanitary principles, of which the Metropolitan Main Drainage works were the outcome, will not even outlast the time of its authors, but is already coming back upon their hands." We need not be surprised, therefore, to find, that Mr. Gladstone presented a Petition to the House of Commons, May 5th, 1879, from the Vestry of Plumstead, complaining of the nuisance arising from the sewage of London, in that part of the river with which they were connected; and praying, that *a prosecution might be instituted* against those who were responsible for the nuisance!

Another result, scarcely less serious than the former, produced by the system of house-drains and water-closets, is the waste of one of the necessaries of life—water. The average quantity of water used as drink only, by each man, woman, and child, is not more than 130 gallons in the year, or somewhat less than 3 pints daily. But, in London, the quantity now consumed for domestic and other purposes—a large proportion being for the water-closets—amounts, according to Mr. Denton, to 25 gallons daily, or 9,125 gallons yearly per head. Some communities, he states, are now receiving 50 gallons per head daily, or 18,250 gallons yearly; and he calculates that London, fifty years hence, if the population goes on increasing at the same ratio as at present, will require 200,000,000 gallons daily. Such a quantity could not be obtained without depriving other localities of their supply, or without drying up the springs that feed the Thames. "If the water which is now required, and which may hereafter be required, for the population of London, were pumped up from the chalk beneath, the higher springs of the London basin, feeding the tributaries of the Thames and other rivers, would be gradually reduced, and *ultimately vanish*, to leave rural towns, villages, houses, and mills, dependent for water upon them (the springs), without any supply at all."* It was at one time proposed to bring water from Wales, but the adjoining populations naturally objected to this robbing of Peter to pay Paul; while, as it so happened, some of these populations were actually short of water not many years since. It is time, therefore, that this waste of water—and more especially the insane proposal for a constant supply, which means a constant waste—like that of the excreta of man, should be arrested, which can only be done by abolishing the present system of house-drains and water-closets. This is the more necessary, at the present time, from the circumstance, that droughts are to be expected, for these always occur at epidemic periods, and have already pre-

* Paper read at the Social Science Institution, December 14th, 1874.

vailed, to a considerable extent in India and Asia, and, to a certain extent, in Europe.

Such are the direful results that have followed the adoption of those measures on which Sanitary Reform is based. The evils consequent on the adoption of the other theory, or the doctrine of contagion, are equally great, and, in a social point of view, still more disastrous.

In the first place, we are expending large sums annually, in order to carry out measures that flow, as a natural result, from the revival of this doctrine, the offspring of the middle ages—an era of darkness, of ignorance, and of superstition. Asylums, or hospitals, are being built in all directions, and in all parts of the country, for the express purpose of isolating the sick poor, labouring under these presumed infectious diseases; although good and substantial infirmaries exist, in nearly every parish, attached to the workhouses; and although the assembling of a large number of sick, under the same roof, would seem to be the very best method, that could be adopted, of spreading the infection, and of rendering the disease more fatal to the inmates. But the matter does not rest here. If the doctrine of contagion be adopted—no matter whether it be true or false—the measures emanating from it will have to be carried out in their integrity, and to the fullest extent. There can be no half measures; nor can there be one law for the poor and another for the rich; the one class being as capable of spreading an infectious disease as the other. As such, it will be necessary, if this doctrine continues to prevail, to isolate the rich as well as the poor; and as there is a large class of persons, even of the highest rank—club-men and those living in lodgings—who could never be isolated in their own homes, asylums will hereafter be required for this class of persons. In this way, the country will be dotted over with infectious, or leper, hospitals, the same as of yore; and God help the poor creatures incarcerated therein, for if the disease did not kill them, the fright would!

The state of private patients may be still worse, as they might be unable to obtain the attendance granted to the inmates of hospitals. Who, in fact, would go near the sick, if the idea be inculcated into the mind of the public, that a patient is a focus of infection? And yet this is what is being done now constantly, although, fortunately, for the interests of humanity, the doctrine is not generally believed in. It was only the other day, that a proposal was made by one writer—a medical man—to fix a card on the door of every house, in which there is a patient with fever, or other so-called infectious disease, as a warning to others not to enter. That may be all very well as regards idle visitors, but suppose that the butcher, the baker, and other tradespeople, became as frightened as the contagionists, and refused to supply the inmates with food, or go to the house? What then? Is the patient to be deserted, and to be left to his fate, like the plague patients in China and other places? A French missionary, settled in China, informed Mr. Blake, that during recent outbreaks of plague at Yünnan, "the patient is, in most cases, deserted like a leper, for fear of contagion. If an elder member of the family is attacked, the best attention he receives is to be placed in a solitary room, with a vessel of water by his side. *The door is secured*, and a pole laid near it, with which, twice a day, the anxious relatives, cautiously peering in, *poke and prod* the sick person, to discover any symptoms of life." * Such, or similar, conduct may be expected to follow the general adoption of the doctrine of contagion, as experience and history both teach us. To find what the results of the

* *Parliamentary Paper, China*, No. 3 (1878), pp. 22, 23.

prevalence of this doctrine are, we have only to turn to the writers of the 14th century, one of whom, Boccacio, in detailing the horrors of the black death of that period, states : "When the evil had become universal, the hearts of all the inhabitants (speaking of Florence) were closed to feelings of pity and humanity. . . . . Thus it was, that one citizen fled from another ; a neighbour from his neighbours ; a relation from his relations ; and, in the end, so completely had terror extinguished every kindlier feeling, that the brother forsook the brother, the sister the sister ; the wife her husband ; and, at last, even the parent his own offspring, and abandoned them, unvisited and unsoothed, to their fate." Nowhere, perhaps, were these results more apparent than during the outbreak of the epidemic cholera in the West Indies, a short account of which has been given in the introductory chapter of the first part of this work. If the doctors did not abandon their patients, as has been but too frequently the case, they must cease to visit them, unless they be shut up within the walls of the house, the asylum or the hospital ; as no better method could be discovered of propagating diseases, if they be infectious, than the visits of medical men from house to house. Fortunately for them, as well as for others, the doctrine of contagion is not true : as it has been my object to show in the first part of this work, and as will be still more evident hereafter. That certain diseases are infectious, and that they can be propagated from individual to individual, is undoubted : but then, in order to produce this effect, the infectious matter must be introduced directly into the blood, either by inoculation, by an abrasion on the surface, or by absorption from some vascular membrane. But diseases are not propagated by the ordinary secretions of the body, or by the emanations given off from the lungs : still less by the contact, either mediate or immediate, of the healthy with the sick. It is, consequently, only those diseases in which a morbid matter is produced, that can be propagated from individual to individual even by inoculation. Even then, the artificial disease is generally milder and different from that of the original affection, as observed in small-pox. Were the doctrine of contagion true, the measures, that have been hitherto adopted, are utterly useless for the purpose for which they have been employed, viz. preventing the spread of epidemic diseases.* As patients could not be isolated before they were attacked; and as they would necessarily come in contact with healthy persons, during their removal, as, also, during the stage of incubation, ready means would thus be afforded for the propagation of diseases—if they be infectious.

That the spread of epidemic diseases cannot be arrested by human means, was clearly shown during the prevalence of the cattle-plague in this country: when the pole-axe—a patent method invented by the veterinarians for the extinction of bovine maladies—was brought into use, but utterly failed to arrest the progress of the disease. It did not stamp out the disease; it only stamped out the cattle. The notion, that it is possible to stamp out a disease, arises from sheer ignorance; and from an unacquaintance with the laws regulating the spread of epidemic diseases: their regular rise and decline, and the limitation of their range in many cases. For instance, it was said that the cattle-plague, which re-appeared a few years since in England, was stamped out, because there were only a few cases that year. But we observe precisely similar results with human diseases, although the pole-axe is not then

* For the proof of this, and the results that followed the establishment of quarantine and isolation of the sick, in the last pestilential epoch, see Part I., Chapter I.

brought into requisition. There are, in fact, few years in which there are not isolated, or sporadic, cases of cholera, small-pox, and other diseases: but it is only in particular years that they spread, or become epidemic. Now suppose that the pole-axe were resorted to, on one of these occasions? The contagionists would declare, that the disease had been stamped out, although this instrument would have had no more to do with the production of this effect, than a telescope has in removing the darkness during an eclipse of the sun. Abundant evidence, in fact, has been adduced, in the fourth chapter of this work, to prove, that the cattle plague, or rinderpest, was neither imported into this country, nor propagated, afterwards, by contagion. And yet, it was precisely in accordance with this doctrine, that not only diseased animals, many of which might have recovered, were slaughtered, but healthy ones also—50,000 healthy animals having been sacrified on the altar of professional ignorance and public delusion. This is not all. Not content with this massacre of the innocents, the flesh of the victims was buried in the ground, and destroyed by quick lime; for fear possibly that the worms should become infected. Nevertheless, many of the inhabitants of Paris, during the late siege, as, also, the soldiers of the Prussian army, consumed the flesh of the animals that died of rinderpest—the disease having appeared among the cattle, both within and without the city, at this peculiar period. M. Decroix, in a recent communication, states, that he partook of the flesh, cooked in a variety of ways, during the whole time that the epidemic lasted— a month—and that, wishing to test its innocuousness to the fullest extent, he ate the flesh *raw*, without experiencing any ill effects.* Of its innocuousness, no doubt can possibly exist; as,

* The *Evening Standard*, April 15th, 1879.

also of the flesh of the animals that died of the cattle plague, at the last pestilential epoch. *

Another murrain, pleuro-pneumonia, is also considered to be an infectious disease, and is so treated, although the reasons for this conclusion are less valid than those that have been adduced for rinderpest. In accordance, therefore, with this doctrine, animals affected with pleuro-pneumonia are consigned to the tender mercy of the executioner, and his pole-axe; although they have committed no crime worthy of death. If, indeed, it be necessary to slaughter animals affected with pleuro-pneumonia, in order to prevent the spread of the disease, the pole-axe ought to be brought into requisition, on the same principle, with human beings, suffering from the same malady, for the two diseases are identical. But although the executioner is not employed on these occasions, the disease is never found to extend, from individual to individual; nor does it in the brute creation, excepting in the imagination of the veterinarians and the contagionists. The only reason for drawing such a conclusion, is the fact, that a greater number of animals than of men is attacked. Those, however, who are acquainted with the laws regulating the extrication of malaria from the surface, will readily understand the cause of the difference; as it is precisely in the districts where cattle are herded—viz., alluvial soils—that this poison is extricated in the greatest abundance.†

It has also been inferred, that the flesh of animals thus affected is deleterious. The question having been referred

* See the communication made to the Academy of Sciences by M. Boulay; and, also, the Circular of the Minister of Agriculture and Commerce, in Part I., pp. 336, 337.

† *Vide Causation and Prevention of Disease:* and the Laws regulating the extrication of Malaria from the surface.

to them, by the Privy Council, the Local Government Board stated; that, "*though not possessed of any conclusive evidence*, that the flesh of pleuro-pneumonia animals is hurtful; they are advised, by their *medical officer*, that it is unsafe for use as human food. The Lords of the Council, in answer to this opinion, expressed their regret, that the Local Government Board is advised, that the flesh of animals, which have been the subject of any febrile disease, should be considered unsafe for human food, and proceed to point out that if such an opinion were acted upon, it would entail so large an outlay, that they would hesitate to continue their order, rendering the slaughter of such cattle compulsory."*

As the opinions of the contagionists have been adopted by the Government authorities; and as it has been concluded, that epizootic maladies are not only propagated from animal to animal, but from country to country, even by healthy animals, as, also, by inanimate objects, the laws regulating the importation of cattle into this country are now so stringent, that they amount almost to a prohibition. In fact, as importation from an infected country is entirely prohibited, and as there are few years in which either rinderpest, pleuro-pneumonia, or the foot-and-mouth disease, does not prevail in those countries, from which we draw our chief supplies, the trade in live animals will be subject hereafter to constant interruption and stoppage. The measures to be adopted for the eradication of disease, when it appears, are still more stringent. A single case of rinderpest, pleuro-pneumonia, or foot-and-mouth disease, entails the sacrifice, or immediate slaughter, of the whole cargo. With risks like these to be run, foreign importers of cattle will either cease to send to this country, or, else, will demand an exorbitant price for them. Meat, there-

* The *British Medical Journal*, November 13th, 1875.

fore, will become scarce and dear, for nearly half our supply, at present, comes from abroad. But the matter does not end here. If it be necessary to slaughter a whole cargo, merely because one animal is affected, we ought, by a parity of reasoning, to adopt the same practice with the flocks and herds in England; whenever a single animal, among them, is found to be suffering from foot-and-mouth disease. Had this practice been adopted, however, from the first appearance of the disease in England, there would have been few cattle left at the present moment, so general has this epizootic been in some years.

Were it a matter of absolute necessity, these evils, like other unavoidable ones, must be put up with, but this is not the case. Pleuro-pneumonia and the foot-and-mouth disease never were, never will be, never can be, imported into this country, and for this reason: they are of spontaneous origin. Both diseases, in fact, made their appearance in England *before* the restrictions on the importation of cattle were removed.* The Cattle Plague Commissioners, in their Report, while referring to pleuro-pneumonia and the foot-and-mouth disease, state: "It is worthy of remark, that neither of these diseases were imported diseases. It was not until some months after pleuro-pneumonia had established itself in the (this) country, that an alteration took place in the tariff, by which live stock came in duty free.† Up to this time, the high rate of duty prevented any importations of foreign cattle or sheep being made." As regards the "foot-and-mouth disease," it made its appearance both in England

* For the histories of these diseases see Part I., Chap. 4, *Epizootics.*

† Pleuro-pneumonia "raged in Ireland," not months, but some years before this date, viz. 1839. (*Census of Ireland*, 1851, p. 220.) It was also very prevalent in 1841, according to the same authority.

and in Ireland, *three* years before the restrictions on the importation of live stock were removed, having commenced in 1839, and having continued to prevail until 1842. In addition to this, the ravages of the disease were greater, and it assumed a more malignant form than it has done since. Although no restrictive measures were taken to arrest its progress, the epidemic had almost entirely subsided before July, 1843, when foreign cattle began to be imported, although not in large numbers, a duty having been imposed, at first, on their admission. There was a general outbreak, again, in 1845, but it subsided in 1846, although no precautionary measures were adopted, and although the import of cattle increased from 16,833, in 1845, to 86,520 in 1846, the duty on foreign stock having been removed in March of this year. Another outbreak occurred in 1852, although the imports, that year, were 23 per cent. less than the year before. There were several fresh outbreaks between this date and 1869, but they were not very general. In the last-named year, "eczema epizootica," which broke out in the spring, was, in August, included, for the first time, among the infectious diseases. But this measure had no influence in arresting the progress of the disease, as " from the passing of the Act to the end of 1871, there were 92,162 fresh outbreaks, and 1,344,625 animals attacked."* The epidemic gradually declined in 1872, and subsided altogether in 1873: although, in the former year, large numbers of diseased animals were imported from Schleswig-Holstein, France, Spain, and Denmark, amounting altogether to 5,295. With these facts before us, to conclude that this disease is not of spontaneous origin in every instance, or that its progress can be arrested by restrictive measures, and the slaughter of healthy animals, shows, in my opinion, not only ignorance,

* *Report of the Veterinary Department of the Privy Council*, 1873.

but a degree of folly, amounting almost to fatuity; yet these are the measures, that are now regularly adopted, to the disgrace of science, to the detriment of the public, and to the injury of individual interests. An example of this has been lately afforded. For fear that disease of some kind *might* be introduced, a large number of valuable cattle, that had been sent over to the Paris Exhibition, were, on their return, placed in quarantine for some weeks at Blackwall, at a cost of several thousand pounds to the Queen, the Prince of Wales, the Duke of Buckingham, and other distinguished owners and breeders. By the interposition of some guardian angel, they fortunately escaped the pole-axe: but this would not have been the case, had one of them caught a cold during the journey, and had an attack of inflammation of the lungs.

Not only is it supposed that the bodies of animals, when alive, and their flesh, when dead, are contagious; but it has also been concluded, that disease can be produced in the human race by means of the milk of cows; not of diseased but of healthy animals. As this "Milk Theory," as it is termed, has not been considered in the first part of this Work, it is desirable to ascertain on what foundation the theory rests.

For this purpose, I will take the outbreak of typhoid fever in Marylebone, which was referred to this cause. It appears, by the report of Dr. Whitmore, the medical officer for Marylebone, that on the 4th August, 1873, Dr. Murchison called on him, and stated, that four of his children were then suffering from enteric fever: and that the disease had also broken out in several families in the immediate neighbourhood. The cause of it he suspected to be the milk, supplied by the Dairy Reform Company; and as it was found, on further inquiry, that nearly all the persons attacked had their milk from the same dairy—

and it could not well have been otherwise, for this company supplied nearly the whole neighbourhood—the conclusion was at once drawn, that this was the source of the infection. Although the warning has been so often given, that coincidence is not cause—if it were, we might, as Sir John Herschel has quaintly remarked, consider the night to be the cause of the day, or *vice versâ*, for these two phenomena are inseparably connected together—this is the rock on which medical theorists are continually wrecking their own reputation, and the welfare and interests of the public. But to proceed. An inquiry was at once instituted, conducted by Dr. Whitmore, Mr. Radcliffe, from the Board of Health, Dr. Murchison, and others; and the following facts were elicited.

It turned out, that the company derived their supply of milk from eight different farms: and as no possible source of infection could be discovered in the dairy in London, it was resolved to visit all these farms in succession. "In seven of these farms," says Dr. Whitmore, "the investigators were unsuccessful in discovering the cause of the outbreak. . . . . On the eighth farm, however, the condition of things, which then existed, coupled with some antecedent facts, which had come to our knowledge, on the evening before we made our inspection, demonstrated *beyond the possibility of any reasonable doubt*, that the fountain and origin of the epidemic had been at last found out. This farm, known as Chilton Grove Farm, is situated some few miles from Thame, Oxfordshire. It had been in the occupation of a Mr. Jessop, who died on the 8th of last June, since which time it has been carried on by his widow. . . . . From information furnished to us by Mr. Humphreys, surgeon, Thame, the medical attendant of Mrs. Jessop and her family, we learned that Mr. Jessop, some short time before his death, was attacked with typhoid fever; and although the return made to the district registrar ascribed the cause of death to 'heart disease,' yet, from the circumstance of Dr. Giles, of Oxford, whom he consulted in the early stages, having pronounced it to be typhoid, as well as from the additional fact, that, some two or three days before he died, copious discharges from the bowels—characteristic of the disease—had taken place, it is very clear that this gentleman had suffered from the fever in an aggravated form, and that a certificate, ascribing his death to 'enteric or typhoid fever,' would have been more correct." Here then we have two or three or more gentlemen, who never saw the patient, taking upon themselves to affirm, that the prognosis of his medical attendant was erroneous; and that he died of a different disease to that which the medical certificate affirmed. And why? Merely because he had hæmorrhage from the bowels, previously to death. But this effect, *per se*, was no proof of the disease being typhoid; for it is equally characteristic of heart disease, of disease of the liver, and certain chronic affections of the bowels. This, in fact, was the cause of the death of George IV.; but there was no talk of typhoid fever in his case. As to Dr. Giles, who only saw the patient at the commencement of the attack, he could not possibly have formed as correct an opinion of the case as Mr. Humphreys, who watched the patient from the commencement to the termination of the illness. Having, however, arrived at the above conclusion, it only remained to ascertain the way in which the patient, who had died exactly two months before, had infected so many persons in London. When evidence is required of a certain nature, testimony, in accordance with the ascertained views of the inquirer, is generally forthcoming; and so it was on the present occasion.

It appears, that the farmhouse and buildings are placed on a slope: the privy being at the highest point—at an altitude of about eight feet—and a well at the lowest. The well, which is bricked, but not cemented, and received its supply of water from a brook a short distance off, is distant from the privy between sixty and seventy feet. Up to the time of the visit, the water in the well "had not been used for drinking for nearly two years, but simply for cooking, washing, and for washing out and cooling the pans." Such being the condition of the premises, "it was obvious," adds Dr. Whitmore, "to myself and the other gentlemen present, that the water was impregnated with the soakage from the privy, and also from the pigstyes and manure heap, which were even in much closer proximity to it, and even upon a higher level. The theory, therefore, by which the infection of the milk is to be explained is as follows: At some time, probably for some days during the illness of Mr. Jessop, his excreta, *intensely impregnated* with typhoid poison, and mixed with other liquid, and decomposing animal matter, was conveyed into the well by percolation; the water of this well, thus poisoned and rendered still more dangerous by drainage from the pigstyes and manure heap, was daily used for washing out the cans; and it is very probable that, after such washings, some small quantity was left accidentally at the bottom of them, and on pouring milk into these cans the whole of it became at once infective."

Such is the theory, now for the facts. Allowing, for the sake of argument, that Mr. Jessop died of typhoid fever, and that the excreta of the patient were thrown into the privy, "it was," as stated by Mr. Emery, at a meeting of the Marylebone vestry, held October 2nd, 1873, to take into consideration the Report of Dr. Whitmore, "a physical impossibility for the sewage-matter to get through eighteen yards of clay to the well—that being the distance from the closet, and there was never any overflow." Then, again, is it within the bounds of probability, that any water should have been left in the cans after they had been washed out: or, that a drop or two of water could have been so infective as to have rendered the milk placed therein thus poisonous? Why! prussic acid itself would have been rendered innocuous after such dilution. But all these questions are at once settled by the fact, that "the discharges from the body of the patient were *buried in a field*;" * where all diseased germs would be decomposed, by contact with the carbon of the soil. They could not, therefore, have found their way either into the brook or into the well. Had it been otherwise, however, the theory would have failed to account for the outbreak in Marylebone. To have rendered the conclusions valid, it would have been necessary to show, that only those persons were attacked, who had taken the milk from this one farm: but no such evidence was offered. On the contrary, it was impossible that all the persons attacked could have drank the milk from this one farm—for it was not mixed, I was told by the secretary of the company, with the milk from the other farms—as there were, it was calculated, at least 500 cases in the districts supplied by this company. Thus, of forty-three families, whose cases were inquired into, three did not have their milk from the suspected source; while, of fifteen patients in the Middlesex Hospital, *three* had not taken any of this milk. Then, again, there were cases in other districts of London, not only at the time, but before

* The *Hour*, September 20th, 1873.

and subsequently to the outbreak, and even before the individual, accused of all this mischief, had been attacked. There were even cases in Marylebone before this, as will be evident by the annexed Table of Deaths, compiled from the returns of the Registrar-General.

TABLE H.—*Number of Deaths from Typhoid Fever, in the following months, and in the undermentioned Districts.*

Month.	West District.	North District.	Central District.	East District.	South District.	Total.
May	8	15*	4	16	17	60
June	7	10†	6	10	14	47
July	12	11‡	6	11	18	58
August ...	22	30‖	13	10	24	99

* Of this number 4 were in Marylebone. † 5 in Marylebone
‡ 4 in Marylebone. ‖ 9 in Marylebone.

Other and important facts may be gleaned by an examination of the above Table. As the cases would bear a nearly exact ratio with the deaths, it appears, that the number of cases, not only in the other districts of London, but even in that of Marylebone, was as great in the month previous to the death of Mr. Jessop (June) as in that subsequent to his death, when the outbreak, it was supposed, had occurred. Then, again, although we are told, that this poisoned milk produced such disastrous results in Marylebone, it nevertheless appears, that the deaths from typhoid fever in the south district, where this cause was not in operation, were actually more numerous than in the north, or Marylebone, district. It is also apparent, that the number of deaths in Marylebone for the three months—June, July, and August—when alone the milk, if infected, could have had any influence, bears only a small proportion to the general mortality, in London, from typhoid fever.

In addition to these facts, there were cases of typhoid fever in London in all the preceding months of the year, and in all the districts. In April, the deaths amounted to 47; in March, to 68; and, in February, to 55. If we add the deaths in May to these, it will give a total of 230 deaths, and, probably, of 4,000 or 5,000 cases, not one of whom could have derived his disease from the alleged source of infection. What a farce, then, to talk of the residents in Marylebone having been infected from the milk they drank! It is clear, that there was some general cause in operation to which these persons succumbed the same as others. What this cause is, it will not be difficult to ascertain. Typhoid fever, as has been pointed out in the first part of this work, and more particularly in a subsequent one,* is a product of malaria, for it has replaced intermittent fever. "The drying (or drainage) of the land," remarks M. Boudin, "or its conversion into a lake, while causing the disappearance or diminution of paludal diseases, appears to predispose the organisation to a new pathological condition, according to the locality, and in which phthisis and typhoid fever play a prominent part."† These conclusions granted, there is an end of the question, for no one, who has had the least acquaintance with this class of diseases, would dream of considering them contagious. A peasant in Spain or in Italy would laugh at the notion.

Although it is thus clear, to the commonest understanding, that the milk supplied by this particular farm had nothing whatever to do with the outbreak of typhoid fever in Marylebone, the whole town was alarmed; people

* *The Antidotal Treatment of Disease.* Chapter, "Typhoid Fever."

† *Étude de Géologie Médicale*, 1848.

were afraid to partake of any kind of milk; infants and young children were deprived of their natural and best sustenance: the owners of the suspected farms were unable to sell their milk, and the sale even of unsuspected liquid was all but suspended. This is not all. "To carry the matter further," remarks one writer, "and leave us without a shred of comfort, a learned professor now comes forward and assures us, that cows, which are themselves free from disease, may give milk which has undergone a poisonous alteration, owing to new principles having been formed by some obscure vital process. An animal that is not injuriously affected, may give off highly noxious secretions. This is a kind of information for which we feel by no means grateful to men of science. It increases neither our happiness nor our safety, but belongs to that description of which the wise man of old said, that he who increased it, increased sorrow. The most practical, and, therefore, the most valuable, piece of advice which occurs in the literature of this Marylebone outbreak is, that milk should be boiled before it is consumed, and we accept it with as much thankfulness as if it were new. But if we might ask a favour of the able men, who are just now enlightening us upon sanitary affairs, it should be, that they will principally consider and help human weakness, and not terrorize us with their superior knowledge. We have seen warnings heaped upon warnings, and precautions dictated after precautions, the minute and never-ending observance of which would make life not worth having upon such terms."* The injury to science is equally great. As one writer has truly remarked, in the sciences a false conclusion is dangerous, not so much because it propagates error, as from the fact, that it pre-

* The *Daily News*, August 25th, 1873.

vents or retards the search after truth. It is time, therefore, that we abandoned all false conclusions, acknowledged our ignorance like honest men and humble seekers after truth—it being, in general, egotistical pride that is the great bar to improvement—and commenced an inquiry *de novo* into the cause—the real, the efficient cause—of epidemic diseases. This is the purport of the following pages.

CHAPTER I.

THE REMOTE CAUSE OF EPIDEMIC DISEASES.

That the causes, hitherto assigned for the production of epidemic diseases, are insufficient to account for either their origin or propagation, is a truth that has been acknowledged by the majority of writers, whose opinions are of any weight. Referring to the epidemic cholera, the Committee of the Academy of Medicine, in Paris, remarks: "The precise, specific, cause of the disease,—that in virtue of which the epidemic exists, and without which it would not have arisen—remains entirely unknown, in spite of all the speculative opinions that have been put forth on the subject."* A writer in the *Lancet*, also, in the historical sketch that was given, in 1832, of the epidemic cholera, observed, while referring to the origin of the disease: "What this cause is, we know not, and we know, that no one else understands it. We cannot speculate upon it; we believe it, in short, to be beyond the reach of human knowledge." "Does the epidemic cholera," asks M. Bouillard, "enter into the number of those diseases of which we know the real cause? Where is the physician, who, with his hand upon his heart, dares to answer in the affirmative. It is necessary to proclaim it openly, the real agent, under the mortal influence of which the cholera morbus has burst upon us, with the rapidity of lightning, has, up to the present moment, completely concealed itself from our researches." It is refreshing, after wading through all

* *Report on the Epidemic Cholera.*

the vain speculations, that have been broached on the subject, to listen to such avowals as these. "It is something," as M. Morin Desbrosses remarks, "to discover our ignorance, and to dare to confess it with honesty. He, who has optical illusions, will certainly take a false route. The blind man, on the contrary, proceeds circumspectly, and uses precautions, which will more probably lead him to his destination."* Having, in the first part of this work, traced all the false routes taken by those who must have been labouring under optical illusions; let us now see whether we cannot, by using the precautions of the blind man, grope our way in the midst of the darkness by which we are surrounded; until we reach that goal, where all the clouds of doubt and scepticism will be removed, and the light of truth be alone visible.

Before the doctrine of contagion was promulgated, the majority of writers, from Hippocrates down, concluded, that the cause of all diseases—both epidemic and endemic—existed in the atmosphere. Hence the aphorism of the father of medicine, *Aer est omnium rex morborumque causa.* This conclusion is generally allowed to hold good, in the present day, with the class of diseases termed endemic, which are known to be produced by the presence in the atmosphere of a poison, to which the term malaria—mal'aria—has been applied by Italian writers, and that of marsh poison by English ones. Hippocrates, however, made a distinction between endemics and epidemics, for although aware that the former were caused by the extrication of a deleterious substance from the soil, he ascribed the latter to a something divine—*to theion*—or to some unknown and inexplicable cause. Sydenham, the father of English medicine, arrived at a similar conclusion. He

* *Histoire de l' Épidémie du Cholera Morbus dans le Département de Loire.*

thought, that epidemic diseases were to be ascribed to "a hidden constitution of the air." Hence the term "epidemic constitution," which has been employed from that time to the present, in order to designate that peculiar, occult, state of the atmosphere, which is supposed to give origin to this class of diseases. Other writers, more bold, or, else, dissatisfied with this state of ignorance, have attempted to define this particular condition of the atmosphere—a circumstance not to be wondered at, when we find, that great and unusual atmospherical vicissitudes are invariably observed at epidemic periods.

Generally speaking, epidemic diseases have been preceded by unusual heat and drought; while they usually return during the summer of cold climates, and the hot months of intertropical ones. Hence, heat has been regarded, by some writers, as one of the chief, exciting, causes of pestilence—a very old idea. It is to the arrows of Apollo, or the rays of the sun, that Homer ascribed the cause of the pestilence from which the Greeks suffered at the siege of Troy. "On mules and dogs the infection first began; and, then, the vengeful arrows fixed in man." Hippocrates has also remarked, that the constitution of the air, which preceded pestilential diseases, was attended, in that part of the world (Greece), by great heat, and by southerly winds. But heat alone cannot be the cause of epidemic diseases, for they sometimes make their appearance in the middle of winter, independently of the fact, that they prevail in all situations and in all latitudes. The pestilence of A.D. 543, according to Procopius, invaded some places in the summer, and others in the winter. Evagrius makes the same remark of the plague of 590. This was also the case with the plague of the 14th century; while the pestilence of 1591 raged in Revel, in the 59th degree of north latitude, in the midst of a severe winter. Small-pox assumes as severe a form in the Arctic regions as within the Tropics; while the plague has committed as great ravages in Russia, even in the midst of winter, as in Egypt. Although confined, in the present day, to the region of the Mediterranean, the plague appears there under very different atmospherical conditions. At Constantinople, it usually breaks out in July, when the temperature is about 95° F.; but, in Egypt, it commences in November, when the thermometer is as low as 68° F. The epidemic cholera, also, on its first invasion, broke out at St. Petersburg, in the middle of winter, and with the thermometer 20° below the freezing point. Heat, therefore, cannot be an exciting cause of epidemic diseases.

Nor can a dry state of the atmosphere have more influence in the production of these diseases, for they sometimes prevail in the very opposite condition, or, that of extreme moisture. Thus, the epidemic cholera commenced in Bengal, on its first invasion, in 1817, in the height of the monsoon, or the rainy season, and when the country about Jessore was covered with sheets of water from the heavy rains. The plague, also, not only prevails in wet weather, as well as in dry, but the ravages of it would appear to be increased during such a state of the atmosphere. Larrey states, that the attacks of plague, in Egypt, were constantly augmented in wet weather. Peignet also remarks: "It is inconceivable how the number of patients increases every time that the atmosphere becomes more humid." Hippocrates and Galen have made the same remark.

Moisture, on the other hand, cannot be necessary for the production of epidemic diseases, which prevail as frequently, if not more frequently, during dry than in wet weather. For instance, at Chuprah and at Arcot, the cholera commenced before the rains had set in, and when the weather, for a month previously, had been excessively dry and sultry. In fact, Mr. Davies, in his letter, attributed the origin of the disease in that spot to the extraordinary dry season and sultry weather; for he adds, "We have every reason to trust for the setting in of the rains, which can alone relieve us from the noxious miasmata." The disease, therefore, as was well observed by a writer in the *Asiatic Journal*, having shown itself at Chuprah after excessive drought, and in Bengal in the midst of continued rains, sets at defiance all theories resting on the state of moisture and dryness of the atmosphere. The same results have been observed in other countries, in hundreds of instances, since that period. Even influenza, contrary to what we should have expected, cannot be referred to atmospherical vicissitudes. It prevails alike within the tropics, in the highest inhabited regions of the north, and during all conditions of the weather. Referring to the influenza that attacked the horses in America, in 1872-3, one writer remarks: "Epizootic influenza does not spread by virtue of any of the recognised atmospheric conditions of cold, heat, humidity, season, climate, or altitude. The disease prevailed, and was propagated in the cold of a northern winter, and in the summer heat of Central America; in the dry air of Minnesota, and in the moist air of the sea-board: at an altitude of 5,000 feet above the sea—at Saltillo, Mexico—and on the low levels of New Orleans—10 feet above sea level—and Galveston, Texas, 5 feet above sea level."*

Again; a change in the electrical state of the atmosphere, especially a diminution of it, has been assigned as the immediate cause of epidemic diseases. This is more particularly the case with Noah Webster, who

* *Philadelphia Medical Times.*

remarks: "It is proved by experiments, that the fibres of living animals are the most perfect conductors of electricity; while the integuments, which cover them, are non-conductors. A consequence of these principles will be that, in all the motions or operations of electricity in the atmosphere, the nerves must be the principal subjects of its influence. Hence, if the atmosphere is, at times, electrified beyond the degree which is usual and necessary, to preserve the body in a due state of excitement, the nerves must be too highly excited; and, under a continued operation of undue stimulus, become extremely irritable and subject to debility."* This debility is, as the writer infers, the cause of the different varieties of fever—both eruptive and ordinary—of influenza, and of the whole class of epidemics. Mr. Orton and other recent writers have adopted the same views, with respect to the epidemic cholera. But the prevalence of epidemics, during every known condition of the atmosphere, when it is in a state of positive as well as of negative electricity, forbids our referring them to the influence of this agent. Besides, the living body, as the writer of the *Madras Report*, on the epidemic cholera, truly remarks, may be negatively electrified, as well as positively, without suffering more inconvenience in one case than in the other. Instances are frequent of men and animals being even struck down by lightning, and remaining stunned for a time, without experiencing any permanent injury. The animal frame, therefore, seems capable of resisting very great changes in the quantity and kind of electricity, without producing the least injury, or any morbid phenomenon. Independently of the above, again to quote the opinion of the writer of the above valuable report, all the atmospherical phenomena, and other circumstances, brought under the

* *History of Epidemics*, vol. 1, p. 316.

head of occasional causes, have, with little or no interruption, existed from the beginning of time, without producing such a disease—at least during historical periods. There are, however, certain facts, which show very clearly, that the electrical condition of the atmosphere is altered at such periods. This was remarked more particularly at St. Petersburg, during the prevalence of the cholera there in 1848. It was stated, in a letter in the *Times* (July 21, 1848) "that scientific men, who have made their observations from the outbreak of the epidemic, in regard to the influence of the magnet, have discovered that during the last few days—since the disease has been on the decrease—its power has considerably increased. It has been proved that, in the course of the week, from the 5th to the 12th July—when the disease was at its height—a magnet which lifted (previously) a weight of 40 lbs., could not lift more than from 4 to 5 lbs. weight during this period. Yesterday, its power had increased to 16 lbs." Again: the epidemic cholera has been frequently ushered in by a storm, or, if prevailing previously, its intensity and malignancy have been immediately increased. This was the fact, during the prevalence of this disease at Lucea, Jamaica, every fresh case, on the day that a storm burst over the town, having presented a malignant form; while the symptoms of those previously attacked, were more or less aggravated. In addition to this, there were several relapses. On the other hand, it has sometimes been observed, that an epidemic, which had commenced or been prevailing during serene and settled weather, has been arrested in its progress, or had its ravages sensibly diminished, by the occurrence of a thunderstorm. Electricity, therefore, cannot be the cause of epidemic diseases.

Although unable to account for the production of this class of diseases by the causes just considered, a variety of circumstances would seem to prove, that the morbific agent is present in the atmosphere. Thus, a change in the direction of the wind has sometimes made a difference in the prevalence or in the progress of the epidemic. During a visitation of the plague in Sweden, in 1710, "it was observed, that when the north wind blew, the mortality was perceptibly less; during an easterly or westerly wind it was somewhat increased; but, when the south wind came, which was the most usual, the pestilence raged like a violent conflagration." * It was also remarked, that the progress of the epidemic cholera, during the first year of its appearance in India, was slower from Ganjam to Nellore than it was from the latter district to the remaining southern portion of the coast, after the wind had set in from the north-east. Again: M. Bally stated, at a meeting of the Academy of Medicine, Paris, that the wind, during the prevalence of cholera at Lille, suddenly became northerly. No fresh cases were observed after this, until the wind again changed, and blew from its old quarter. Nowhere, perhaps, was the influence of the wind, in increasing the ravages of a disease, better observed than at Trinidad, during the prevalence of the epidemic cholera in that island, in 1854.

Port of Spain, the capital of Trinidad, is a very well-built town, the streets running in a straight line, and intersecting each other at right angles. The town, in fact, forms nearly a square—one side facing the north, and the opposite one the south, or nearly so. As Trinidad lies in the track of the N.E. trade wind—changed, as it blows over the town of Port of Spain, by the configuration of the land, or the neighbouring mountains, into a nearly easterly wind—it follows, that the houses, in those

* Broberg, *On the Plague in Stockholm.*

streets running parallel to the direction of the wind, will be all equally exposed to its influence. In those streets, on the contrary, that are perpendicular to the direction of the wind, the houses on the windward side would necessarily be more exposed to its influence than those on the leeward side. This will be rendered more apparent by a reference to the sketch in the Appendix, made from memory; a plan of the town, that I brought away with me, having been destroyed in the fire at the Pantechnicon, a few years since.

Dr. Clarke, staff surgeon, then stationed in the island, wishing to ascertain the exact mortality that had occurred in the town, and finding it impossible to obtain correct data, in any other way, took upon himself the task of going from house to house, in order to ascertain the number of deaths in each. In so doing, some curious facts, which are exhibited in the following Table, copied from Dr. Clarke's Report, became manifest.

TABLE A.—*Rate of Mortality in the undermentioned Streets, in Port of Spain.*

Streets running North and South.	Deaths *per cent.* of the population.	
	East side.	West side.
1. Duncan Street	11.8	10.0
2. Nelson "	11.2	9.7
3. George "	12.6	7.9
4. Charlotte "	11.4	7.5
5. Henry "	11.1	8.9
6. Chacon "	10.2	7.6
7. Edward "	10.7	5.0
8. Vincent "	8.8	6.5
Average...	10.54	7.42
Difference	3.32	

NOTE.—The east side, in these streets, is the windward side, the west, the leeward side. Duncan Street, again, is the most windward of the above streets, Vincent Street, the most leeward.

By a reference to the preceding Table, it will be seen that the proportion of deaths, to population, in the houses on the windward side of those streets, that are perpendicular to the wind, was three and four per cent. higher than in the houses on the leeward side of the same streets. In some streets, in which the houses, on the windward side, were more exposed than in others, the rate was still higher.

Not only was there a difference, in the rate of mortality, in the houses on the two sides of these streets, but there was also a difference on the windward and leeward side of the town. In the former, the rate of mortality was 14.10 per cent. of the population; and, in the latter, 8.1—a difference of 6 per cent. So, again, there was nearly the same variation in the windward and the leeward streets. For instance, in Duncan Street, the deaths amounted to 10.54 per cent.: in the most leeward—a street beyond Vincent Street—to only 6.2 per cent. On the other hand, there was no perceptible difference in the number of deaths on the two sides of those streets that run parallel to the wind. The only variation was at the two extremities of these streets. Thus, in Upper Princes Street, which is the windward end, the rate of mortality was 7.8 per cent.; but in Lower Princes Street, the leeward end of the same street, the rate was only 2.1. In Queen Street, which is rather more exposed to the trade wind than Princes Street, the rate was 11 per cent. at the east, or windward end; 7.8 in the middle, and 6.0 at the western extremity. Another result is worth recording. The mortality was greater in the wide, open, streets than in narrow ones. In Frederick Street, the narrowest and most confined street in the town, the deaths only amounted to 2.1 per cent. of the population; the average of the other, or open, streets being 11.2 per cent. On the other hand, those houses in the suburbs that stood alone, and which, therefore, were particularly exposed to the influence of the wind, suffered more than any others.

As the influence of the wind, in this instance, is self-evident, what, we may ask, was the occult cause of these different effects? Dr. Clarke and others thought the phenomenon could be explained on the supposition, that the emanations in the back yards of the houses, on the windward side of the streets, that run perpendicular to the trade wind, were driven into these houses; while they were unable to enter, or were driven away from, the houses on the opposite side. These conclusions might be satisfactory enough, provided only it were shown, that such emanations are sufficient to produce the effects under consideration; but that cannot be the case, if my previous deductions be of any value. Such an explanation, again, would be insufficient to account for the result observed in the other streets—those that run parallel to the wind. As, in these instances, the wind must have blown over the backs as well as the fronts of the houses, there would necessarily have been an accumulation of the emanations from the yards at the leeward end of these streets: where also the mortality, according to the above hypothesis, ought to have been the greatest. The contrary, however, is the fact: the mortality, as we have seen, being actually 5.1 per cent. less at the leeward than at the windward extremity of these streets. The emanations from the yards could not, therefore, have been the cause of the variations observed in the mortality of these different streets. Besides, we have observed the same phenomenon in other situations, where this cause was not in operation. In London, during the outbreak of cholera, in St. James' parish, in 1854, it was remarked, that the *east side* of the streets running north and south—the dwelling houses being about equal on the two sides—

suffered most: in streets running east and west, the *south side* was, generally, most affected. We may therefore conclude, that the direction of the wind was S.E.

Another circumstance, confirmative of the conclusion, that the agent productive of epidemic diseases is present in the atmosphere, is the following. It was a general rule, that the residents of the houses, in the villages in the interior of Trinidad, situated on the high road, suffered severely from attacks of cholera; while those living in huts, *in the bush*, as generally escaped, or were only slightly visited. The same phenomenon has been remarked in India. The chief commissioner of the Chulleesghur division of the central provinces stated, in his Report, that the villages in the open plain suffered more than those in the forest: although the inhabitants of the latter are poorer and fare worse than those in the villages and towns.* So, also, in Jamaica, during the severe visitation of cholera, in that island, in 1850, the highest rate of mortality was in the small villages and settlements in the interior; the lowest, in the large towns—the rate varying from 15 per cent. in the latter to 70, 80, nay 90, per cent. in the former. Nearly all these villages are situated in hilly districts, and on elevated plains; while they are much cleaner than the houses in the towns, and better ventilated—being built mostly of bamboos, through the interstices of which the air rushes as it would through a sieve. Hence they are more exposed to the influence of the external air than the houses in the towns.

It is also worthy of remark, that females suffered more than males, in the West Indies, from the ravages of cholera.† In the East, however, the contrary is the case,

* Dr. Bryden's *Report*, p. 234.

† In the districts under my immediate superintendence, 42 per cent. of those attacked were males, and 58 females.

females there being much less liable to attacks of cholera than males. The difference is easily explained. In the East, females are more confined to the house than males; while, in the West, they work in the fields, and carry the produce to market. In addition to this, during the prevalence of the epidemic, they actually did nearly all the out-door work; while their lords and masters—the lazy, good-for-nothing negroes—lay skulking at home, having refused to do any work. It also appears, from the statistics collected by Dr. Guy, that domestic servants —the class that remains the most in-doors—suffered less from the ravages of cholera in London, in 1849, than other classes. On the other hand, those that live principally in the open air—cabmen, watermen, &c.—suffered most. The inmates of the different prisons, asylums and workhouses, were only slightly visited at this period: while the patients in the hospitals, both in London and Paris, entirely escaped. This is the more worthy of note, as cholera patients in Paris were actually taken into the wards that contained other patients—thus proving, most conclusively, that this disease is not contagious, and that it is not, and cannot be, propagated from individual to individual, under any circumstances whatever. These facts are not new. Sir Gilbert Blane has stated, that the persons in the jail, hospital, and poor-houses, of Philadelphia remained exempt from the pestilential epidemic (of yellow fever) in its utmost rage; and the same result was observed with the prisoners of war in Jamaica. In Barcelona, also, during the prevalence of yellow fever there, at the commencement of the present century, when more than 20,000 perished in the course of four months, —a third of the population—no class was spared, excepting those in the prisons, the poor-houses, and some charitable institutions!

That the immunity, in these instances, is to be referred to the exclusion of the external air, may be inferred, not only from what has gone before, but, also, from the following circumstance, narrated by Captain Claridge, author of a work on Hydropathy. "In a former visitation of the disease (cholera) in Avignon, to give air to one of the non-infected wards in the hospital, the medical man ordered the windows to be opened: immediately, on the order being complied with, it is an attested fact, a number of the patients, in that ward, were seized with cholera. They were all removed to the infected department: the windows of the non-affected wards were all closed, by which means the cholera was kept out." It was also remarked, in one of the severe visitations of yellow fever, in the West Indies, that those who exposed themselves to the *outside air*, or, even, to *a current of air* within the house, were suddenly attacked with the disease.*

* With these facts before us, what are we to say to the following recommendations, among others, issued on the approach of cholera, in 1865, by the then medical officer of the Privy Council: "Ample ventilation should be enforced. It should be seen that window-frames are made to open, and that windows are sufficiently opened. Especially where any kind of infective fever has begun, it is essential, both for patients and for persons who are about them, that the sick room and the sick house be *constantly traversed* by streams of fresh air." All we can say is, that doctors differ on this point, as well as on many others. Windows, I should say, were made to be shut, otherwise we might as well be without them, as is the case with most of the barracks in Spain. It unfortunately happened, however, during the prevalence of cholera there in 1834, that the infantry soldiers, although possessing what the above writer considers so great an advantage, suffered more from attacks of the disease than any other class. But the cavalry soldiers, who, in that primitive country, are in the habit of sleeping in the stable with their horses, and who are thus obliged to inhale, what some persons call, the impure, contaminated, expired air of their equine companions, were only slightly visited. Not

Similar results have been observed during the prevalence of epizootic diseases. Mr. Youatt, speaking of the influenza which attacked horses in 1833, remarks: "Two or three shut up in a comparatively *close stable* would escape. So, also, of 30 distributed through 10 or 15 little (and therefore close) stables, not one would be affected; but in a stable containing 10 or 12, although proportionably larger and *more ventilated*, the disease would assuredly appear; and if it does enter one of the largest stables, almost every horse will be affected."* In a paper written by Mr. T. Greaves, M.R.V.C., we find the following remarks. After stating, that the contagious nature of the disease—pleuro-pneumonia—is not yet fairly established, the writer adds: "We see situated upon yonder high hill a dairy, which no expense has been spared to render everything that is likely to contribute to and ensure health. . . . We see, that the sweet fresh breath of Heaven plays about it, and sweeps freely through the place; the ventilating shaft with the ingress upon the ground surface, and the temperature always scrupulously attended to. In this place, there are no drains, no 'grids,' nor manure-heaps, permitted to accumulate; but, in every department, cleanliness, regularity and care, are diligently and rigorously persisted in; and yet, what are the results? The morbific influence, the fell destroyer, has taken up its abode here, with only limited periods of absence; and would appear to be perfectly irrepressible by any, and every known, human agency. We see (it may be) at the very next farm, where no pretensions

only should the windows of private houses, but those of hospitals, also, be kept shut, during the prevalence of epidemic diseases: and care ought to be taken, that the *nurses do not open them*, after the doctor's visit.—Vide, *Notes on Nursing*. By Miss Nightingale, who recommends this rebellious act!!

* *The Veterinarian*, 1833, p. 117.

whatever to care or cleanliness are observed; where the hovel is so low, that you cannot stand upright in it; and the walls, and the top of the building, strangers to a brush of any kind, perhaps for thirty years; where there is *no ingress nor egress* for a breath of air, and where the manure-heap is within one yard of the door, and only removed at rare intervals of time; where the green, fetid, putrid, decomposing, animal and vegetable matter is reeking, and disgusting to the senses; yet, strange as it may appear, the disease has never visited this loathsome place. . . . How can this phenomenon be accounted for?" The writer concludes, that the disease is the effect of an aerial poison, but how produced "science is not yet able to make known to us."* This, no doubt, is the right conclusion, for the only way in which we can account for the effects under consideration is, by concluding, that a deleterious substance is present in the atmosphere; and that it exists to a greater extent in the external air than in that of the interior of buildings, houses, stables, &c. That the poison productive of epidemic diseases is present in the atmosphere, we may conclude, not only from what has gone before, but also from the following interesting observation or experiment. It was ascertained by Dr. Prout, during the prevalence of the cholera in London, in 1832, that the ordinary lateritious sediments disappeared from the urine, their place being supplied by oxalic acid. Dr. Prout further ascertained, that this state of the secretions was connected with a positive increase in the weight of the atmosphere, similar to what might be produced by the diffusion of a heavy, gaseous, substance in the lower atmospheric strata.† Observing these facts, certain writers, more especially those resident in inter-

* *The Veterinarian*, vol. 39, p. 460—1864.

† *Researches into the weight of the Atmosphere.*

tropical climates, have referred the production of epidemic diseases to the poison termed malaria. This agent, which, as previously mentioned, is productive of the class of diseases termed endemic, is usually considered to be a product of animal and vegetable decomposition—substances that exist constantly in the soil of those localities from which malaria is extricated in the greatest abundance. Without waiting to ascertain the truth of this conclusion—this part of the subject having been fully discussed on a previous occasion *—it is sufficient now to remark, that malaria cannot be productive of epidemic diseases, if we conclude, as is generally the case, that this agent is only extricated from the alluvial districts of inter-tropical climates, and the marshes of extra-tropical ones. Although prevailing to the greatest extent in alluvial districts, epidemics are to be met with in all situations—on elevated as well as in low localities, on secondary, and, sometimes, on primary formations. Nor can the agent be generated in one situation, and then be transported by winds or currents of air to other localities; for epidemic diseases have been known to progress in the face of a strong monsoon—a wind that blows regularly, for some months, from the same point of the compass. For instance, " the epidemic cholera travelled from north to south of the Indian peninsula with remarkable regularity, appearing in the line of 20° of northern latitude, in the beginning of 1818, and reaching 8° north latitude on the 1st January, 1819, being about a degree a month. During this progress, far from being assisted by winds, the disease must have frequently travelled in direct opposition to the currents, and seems never to have been retarded or advanced by their direction." † This circumstance was better observed, and more

* Vide *Causation and Prevention of Disease.*

† *Bengal Report on the Epidemic Cholera.*

particularly remarked, in India, on account of the prevalence of particular winds, in this part of the globe, at particular seasons of the year, and their subsidence at fixed periods. Besides, epidemic diseases have not only attacked bodies of men on land; they have also infected ships at sea, when they were hundreds of leagues from the shore, and where, of course, the operation of an agent from such a source could not possibly be experienced—malaria becoming innocuous when largely diluted in the atmosphere. Thus persons, residing only three or four hundred yards above the level of the marsh or jungle, escape the diseases, which are frequently productive of great mortality among those who inhabit spots nearer the source, whence the poison is given out. If these deductions be correct, it follows that we must look to some other source, for the generation of the agent productive of epidemic diseases, than that usually considered to give origin to malaria. Nor can we infer that the poison present in the atmosphere, is derived from the bodies or the breath of the sick, or other infected source. The irruption is, in many instances, too sudden to allow of such a conclusion for a single moment. On board the "Britannia," in the Black Sea, in 1854, men were attacked with cholera so suddenly, that they fell down in a state of collapse, in all parts of the ship, and even on the yards, *while reefing sails.* I witnessed a similar attack on board the late East India Company's ship "Canning," during her voyage from England to China, and while proceeding up the China Sea. In this case, infection was out of the question, as, in addition to the suddenness of the attack, we had been at sea three months, while the event occurred previously to the advent of the epidemic cholera in England. At Punderpoor, also, men were seen tumbling over each other in the public streets, as if struck by lightning; while the visitation ceased at the end of three days—a sure proof that the disease was neither caused nor propagated by contagion.

But if we infer, that the agent productive of epidemic diseases is present in the atmosphere of particular places; and if it be also concluded, that it is not produced by any alteration in the chemical affinities and properties of the air itself; nor generated on the surface of the earth, or, in the bodies of men, whence, we may ask, can this invisible substance be derived? If unable to account for the production of the poison above the surface, our only resource is, to glance into the interior of the globe, with the view of ascertaining whether there be any process going on there capable of giving origin to a poisonous matter. Now there is a process in constant operation in the bowels of the earth, and which gives rise, at particular periods, to certain effects cognizable to our senses: to this process the term *volcanic action* has been applied. But then it so happens, that this process is a silent and invisible one; for we are unable to penetrate into the interior of the globe, and to view the operations of nature in this her hidden laboratory. It is impossible, therefore, to ascertain its existence, except by the occurrence on the surface of some of those phenomena, known to be produced by volcanic action. The principal and the most striking of the effects, directly produced by the agency of this cause, are, as is well and commonly known, the volcano and the earthquake. "Now if we contemplate a volcano, whilst in a state of vigorous action, the phenomena presented to us are at once so peculiar, and so impressive, that it would seem unnecessary to be at the trouble of defining that, which the commonest observer could hardly fail to recognise again, in whatever part of the globe it might fall under his observation. The evolution of smoke and ignited matter from an orifice in the earth, generally situated on the summit or flanks of a conical mountain, the ejection of fragments of scoriæ, bearing a near resemblance in their condition and aspect to the ashes of an iron foundry, the sudden and copious extrication of elastic fluids, with their natural concomitants, noise, and concussion of the rocks, through which they force their way, are circumstances, which strikingly impress upon the imagination the paroxysms of volcanic action; and appear to distinguish this from all the other operations of nature."* But as the shock of the earthquake, and the eruption of the volcano, are the principal signs we have of this action being in existence, the only direct evidence, it may be considered, that could be adduced in support of the above hypothesis, would be the occurrence of these phenomena simultaneously with the outbreak of epidemic diseases. Such proof, however, is generally wanting; for though, as will hereafter appear, epidemics are sometimes accompanied by earthquakes, these diseases frequently prevail without being preceded or accompanied by this phenomenon—while the influence of volcanos must be too limited to allow us to draw any deductions from this source, in respect to general plagues or epidemics. "If, however," as the author before quoted truly remarks, "we limit our view of volcanic action to the phenomena attendant on the eruption of a volcano, and the shock of the earthquake, we exclude from our definition a series of effects evidently allied to the former, and, perhaps, equally illustrative of its real nature. How different, for example, are the eruptions of Vesuvius and Ætna, or any other mountain which emits a stream of lava, or melted matter, from the emanations of gas and vapour, which arise in situations where no vent exists; or, from the increased temperature of certain springs in the neighbourhood of active and extinct volcanos; or, the

* *Ency. Metrop.*, Art. Geology.

evolution of carbonic acid, and other gases, from the water of these as well as all other thermal springs. Yet the connection of all these phenomena, with the action which gives rise to the eruption of the volcano and the discharge of melted matter from the crater, is as well established now, as is the relation of subterranean concussions or earthquakes with the volcanic process." But, although these various phenomena may, when present, afford conclusive proof of the existence of volcanic action, we are unable to derive any evidence from this source in support of our hypothesis—for these effects are seldom witnessed, except at periods subsequent to the appearance of the volcano and the earthquake, and in spots, where these phenomena have been observed; or, where evidence exists of their former occurrence. As, therefore, these particular effects are only met with in certain localities—being scattered, like the volcano itself, irregularly over the earth's surface, while they occupy but a small portion of the habitable globe—and as epidemics extend over every part, and in situations where these phenomena are not observed, it follows, that we can derive no evidence in proof of our hypothesis from the existence of the latter, any more than from the former signs of volcanic action. True, there are certain other and general phenomena, which usually accompany the march of pestilential diseases, and which, as will be inferred hereafter, are effects of the same cause; but as these phenomena are not now considered to be signs of the existence of volcanic action, it would be wrong to draw any conclusions from this source, until other and more positive proofs are obtained in support of this connection. We must therefore adopt another and a different method, in order to prove the proposition with which we started.

The first thing, as Sir John Herschel informs us, that a philosophical mind considers, when any new phenomenon presents itself, is its explanation or reference to an immediate producing cause. If that cannot be ascertained, the next is, to generalize the phenomenon, and to include it, with others analogous to it, in the expression of some law, in the hope that its consideration, in a more advanced state of knowledge, may lead to the discovery of an adequate proximate cause.* The same advice has been given by Laplace,† who says: "*La méthode la plus sure, qui puisse nous guider, dans la recherche de la vérité, consiste à s'élever, par induction, des phénomènes aux lois, et des lois aux forces.*"‡ This is, in fact, the inductive method of philosophising invented by Lord Bacon, and applied, with so much success, to every branch of science by a number of philosophers, who have followed in the path marked out by this prophet of the art, or father of experimental philosophy, as he has been justly termed. Before his time, philosophers were in the habit of pursuing a course, that was subsequently adopted by Descartes, viz., to guess at the cause, and then endeavour to account for the effects by a reference to this power, or agent, of their own creation. This is very different to the method of Bacon, who has laid down the following axiom: "MAN, THE SERVANT AND INTERPRETER OF NATURE, UNDERSTANDS AND REDUCES TO PRACTICE JUST SO MUCH AS HE HAS ACTUALLY EXPERIENCED OF NATURE'S LAWS; MORE HE CAN NEITHER KNOW NOR ACHIEVE."§ Instead, therefore, of proceeding from causes to effects, he pursued a directly contrary order; and proceeded upwards from effects to causes; or,

* *On the Study of Natural Philosophy.*

† *Essai Philosophique sur les Probabilités.*

‡ *Forces* or *causes*—primary, or remote, cause as it is now usually termed.

§ *Novum Organum Scientiarum.*

as he termed it, raising axioms from particular instances.

Now, if we generalize the phenomena attendant on the march of epidemics, we shall find, that they are so regular and uniform, as to deserve to be set down as laws of this class of diseases. More than this, if we compare these laws with those attendant on volcanic action, it will be found, that they are the same, or similar, as will be apparent by the recital of a few of the principal phenomena observed during the operation of this process on the crust of the globe.

LAW I. THE FIRST AND MOST SINGULAR LAW, WHICH MAY BE NOTICED, IS THAT WHICH CAUSES THE EFFECTS OF VOLCANIC ACTION TO BE FELT OR WITNESSED ALONG PARTICULAR LINES OF THE EARTH'S SURFACE.

To be convinced of this, we have only to cast our eyes over any one of the principal volcanic regions, when we shall remark, that a series of vents extends along, at a greater or less distance, either in a straight or curvilinear direction; and this too over considerable portions of the earth's surface.* As an example of the first, we may refer to the Andes, where, "from Chili to the north of Mexico, there is a line of volcanos, *so uninterrupted*, that it is rare to find an intervening degree of latitude, in which there is not an active vent; and it seems probable, that they will hereafter be found to extend from Cape Horn to California, or even, perhaps, to New Madrid, in the United States—a *distance as great as the pole from the equator*.† Although extending to this distance in one continuous and uninterrupted line, the volcanic action is confined, as well as the effects resulting from it, to very narrow boundaries on either side. "In regard to the western limits of this region," observes the same writer, "they lie deep beneath

* See Map 1 in the Appendix.

† *Lyell's Principles of Geology.* Vol. I., p. 586.

the waves of the Pacific, and must continue unknown to us. On the east, they do not appear to be prolonged to a great distance, for there seems to be no indication of volcanic disturbance in Guinea, Brazil, and Buenos Ayres." A remarkable example of the other variation or curvilinear direction is to be found in the Pacific Ocean. "From the Philippine Islands, a range of volcanic vents proceeds to nearly 10° latitude S. ranges westward along this parallel for about 25° of longitude, and then turns up north-west diagonally through about 25° of latitude. This line, which, when represented on maps, resembles an enormous fish-hook, passes from the Philippines, by the north-east point of Celebes, Gelolo, the Volcanic Isles between New Guinea and Timor, Floris, Sumbawa, Java, and Sumatra to Barren Island." Another curvilinear region, although not so well marked and clearly defined, exists in the Atlantic Ocean; the centre of this region being the West India Islands. For reasons that will subsequently appear, the eastern apex of the line, as I infer, extends as far as the southern shores of Spain. Stretching thence, along the western coast of Africa, it passes through the West India Islands, and then turns up along the eastern coast of America, as far as the 40° of north latitude, if not farther.

The principal volcanic region in the old world extends, from east to west, for the distance of about 1,000 miles from the Caspian Sea to the Azores. From south to north, it reaches from about the 35th to the 45th degree of latitude. Its western limits, says Lyell, are the ocean, but it is impossible to ascertain how far it may be prolonged in that direction; we only know, from the phenomena that have been observed at different periods, that the line extends across the continent of America. Nor can we assign with precision its extreme eastern boundaries, since the country beyond the Caspian, and sea of Arat, is scarcely known. An attentive consideration of the phenomena which have been observed in this part of the world, from time to time, leads distinctly to the conclusion, that the volcanic action extends along the centre of this region in a line from east to west; for while the effects of earthquakes, which have occurred at a given point, have been felt hundred of miles from the centre of concussion, in *a linear or western direction,* scarcely any effect has been observed in places situated but a comparatively short distance to the north or south of this particular line. This phenomenon was particularly noted in the earthquake at Lisbon; for the concussion was severely felt by ships at sea, hundreds of miles to the westward of the spot where it first commenced; while places but slightly removed from this line, to the north and south, experienced no shock, only slight agitation in the waters of the sea, rivers, ponds, etc. It would also be an easy task to show, if space were afforded for the purpose, that the concussions which have been felt in this region, and even at the farthest extremities of the volcanic line, have an intimate connection with the volcanos of Ætna and Vesuvius; inasmuch as, previously to an eruption of either volcano, earthquakes have generally been experienced along some portion of this particular line, while these have invariably ceased, as soon as the melted matter has found its way to the surface. Other signs of internal action along these particular lines, and the fact, that two vents are seldom in a state of activity at the same time; while the discharge of matter from one outlet, invariably lessens, or arrests, that from another, sufficiently attest their continuity beneath the surface. Thus, the volcanos in different parts of Iceland, as well as those in the Phlygrœan Fields, are observed, as Lyell states, to be in activity by turns,—one *vent often serving for a time as a safety valve to the rest.*

In other instances, however, or, in other districts, where no volcanic vent exists, and where concussions are alone observed, the same law is found to prevail. Thus, a shock having been experienced at a given spot, it is speedily propagated to another and a distant point, *and always along some particular and well defined line,* being frequently felt hundreds of miles from the part where it first manifests its effects; while places removed only a short distance from this line, on either side, are scarcely, if at all affected. In the earthquake at Chili, the shock was felt *simultaneously* throughout a space of *one thousand two hundred miles* from north to south; while places situated a few miles only on either side of this particular line, were not at all affected. Again; on the 17th February, 1827, a violent earthquake was felt at Santa Fé de Bagota, in Columbia; and, *on the same day,* at a town in Siberia. It is worthy of remark, adds M. le Baron Humboldt, to whom we are indebted for this account, that the direction of the shock in Columbia was from south-east to north-west, and that this direction points towards Siberia. Not less interesting is the circumstance, that the line from Columbia towards Siberia strikes the most remarkable volcanic region in Mexico, and is parallel to the principal range of American mountains. This may be received as a proof, says the above writer, *that the operation of earthquakes is propagated in a linear direction:* while, we may add, it is no less a proof, that their effects are felt, at the same moment, over large portions of the terrestrial sphere.

In the diseases under consideration, one of their most characteristic features is their progression along, and prevalence over, particular lines of the earth's surface.

Although, like a range of volcanic vents, they frequently extend over the whole or a considerable part of one of the great circles of the terrestrial sphere, yet their effects are felt but at a comparatively short distance on either side of this particular line. So defined is the boundary, which marks their course, that it has not been an unfrequent occurrence to observe one side of a river affected, while the other has remained untouched; nay, even the same morbific line has intersected a town, attacking a suburb to the exclusion of the city, or *vice versâ;* and one side of the street in preference to the other.

In the black death of the 14th century, the most destructive plague of which we have any record, this law was particularly striking and well marked. This disease, as appears by the unanimous testimony of all historians, first commenced in China, or, according to Dr. Mead, in the kingdom of *Cathay*, to the northward of China; whence it spread, in a westerly direction, across the continent of Asia to Constantinople. We are not acquainted with its exact route in this part of the world: but we are told, that India was nearly depopulated, while Tartary, the Tartar kingdom of Kaptshack and the contiguous countries were covered with the dead. It is also certain, from the records yet preserved, that the plague, which broke out in Constantinople in the year 1347, was the same as that which previously prevailed in the countries to the east of this city; for the historians of that period state, that the disease had been brought from the northern coast of the Black Sea; or, according to the general Byzantine designation, "from the country of the hyperborean Scythians," after having depopulated the intermediate countries. When, however, it had reached Constantinople, the great centre at that period of commercial intercourse, the disease, instead of spreading, like radii from a centre, in all directions, took one particular and well-defined course by the islands and shores of the Mediterranean, until it reached the south of France. At this point, the epidemic, changing its direction from a westerly to a northerly one, passed through France and England, and thence to the northern kingdoms of Europe,—Sweden, Norway, and Russia, being visited in succession. "Instead of advancing in a north-westerly direction from Tauris and from the Caspian Sea, it had thus made the great circuit of the Black Sea by way of Constantinople, southern and central Europe, England, and the northern kingdoms, before it reached the Russian territories."* †

In the epidemic cholera, also—a disease which, like the former, had its origin in Asia, and which traversed the peninsula of India, and the heart of Persia, by one particular and principal route, to the borders of the Caspian Sea—the same law has been observed.§ Instead of following in the track of the black death, and extending

* Hecker: *The Black Death of the 14th century.*

† Referring to the Siberian plague, then prevailing in Russia, Mr. Simon remarks: "Terrible inflictions have, before now, come to us by that line of transit; and cholera is not the only pestilence, which has thus come. Apparently, it was through Russia, and, perhaps, as a Siberian plague, that, five centuries ago, the Black Death came to England."‡ This conclusion is not only contrary to fact, but it is, at the same time, a singular one, coming from a writer in Mr. Simon's position, and who, we might have concluded, would, at all events, have been acquainted with the history of diseases, if not with their causes. Independently of the fact, that the plague travelled from England to Russia, at that period, *not* from Russia to England, the Siberian plague is a totally different disease to the Black Death! ‡ 8th Report, page 26.

§ Whether the line thus traversed be volcanic, will be considered more particularly hereafter: it is sufficient now to remark, that, if it be, the line must be a new one; no indication of volcanic action having been observed previously, in several of the countries passed over by the epidemic.

along the shores of the Mediterranean, it proceeded in a northerly direction into the heart of the Russian dominions. From this, taking a bend to the west and then to the south, it traversed Poland, Prussia, and Germany, by a peculiar and well marked route, until it reached England and the north of France, and, at a later period, Portugal, Spain, the south of France and Italy; thus taking, from the borders of the Caspian Sea, the contrary course to that pursued by the preceding disease. This circumstance is the more remarkable, inasmuch as the disease had reached, by another branch, or offset, the eastern and southern shores of the Mediterranean as early as the year 1823; and Egypt, in 1831; whence it threatened the isle of Cyprus on one side, and Greece and Italy on the other. These countries, however, entirely escaped at that period, while they were subsequently invaded in another and opposite direction, thus proving, most satisfactorily, that this epidemic, like most others, pursues it own peculiar and well-marked course, independently of human assistance, and, apparently, against the stream of commercial intercourse. The epidemic spread, at the same time, from its first point of departure, Jessore, in the opposite direction, having extended to Sumatra, Java, Burmah, Manilla, and China, apparently over the old volcanic band of the Sunda and Molucca Islands.

The same law has been found to hold good with epizootic diseases, which have invariably progressed along the same line of route as the diseases of the human race. This was the case during the last pestilential epoch, with all the epizootics of which we have any record; for they progressed regularly from east to west, like the black death, or the plague, across the continent of Asia and Europe. Not that this law is invariably observed, as diseases—both epidemic and epizootic—like earthquakes, are sometimes progressive, sometimes local. When, however, they do pass from one country or region to another, it is invariably along the same lines of the terrestrial sphere. The bovine maladies of the present pestilential epoch—such as the foot-and-mouth disease, pleuro-pneumonia, and the cattle plague—have obeyed the same law.

A complete history of the foot-and-mouth disease is wanting: we only know, that it prevailed on the Continent previously to its appearance in England in 1839, while it has been recognised in India. As, however, the cattle in India are not numerous, and their flesh rarely employed as food, it did not attract attention until lately. There can be little doubt, however, that it sprang up there soon after the appearance of the epidemic cholera, for such has been the case in Europe. Although we have accounts of the prevalence of a similar disease during the last pestilential epoch; and although isolated, or sporadic, outbreaks occurred in a few instances, at the end of the last and beginning of the present century, it did not appear in an epidemic form, until about the period of the first outbreak of cholera in Europe. The first account we have of it is in 1834, when it was prevalent in Hungary, Lower Austria, Bohemia, Saxony, and Prussia. In 1837, it appeared in the Vosges, a chain of mountains to the north-east of France, and in Switzerland. Thence, it extended over France and Holland to England, which it reached in 1839, as, also, Ireland. We have a more accurate account of pleuro-pneumonia, which, according to the report of Mr. Vice-Consul Blackwood, commenced in the steppes of Southern Russia soon after the appearance there of the epidemic cholera: but it existed, in all probability, some years previously, although not generally perhaps: having appeared at Dantzic as early as 1821, in

Belgium in 1828, the Rhine Provinces in 1830, and at Brandenburg in 1832. Be this as it may, as soon as the disease assumed an epidemic form, it spread from the south to the north of Russia, and thence through Poland, Prussia, and Mecklenburg, to Holstein. It also appeared, at the same time, if not previously, in Ireland, as the Census Commissioners for Ireland, in their Report, under date 1839, remark: "The epizootic of pleuro-pneumonia among cattle, which had spread so extensively over Europe, for some time anterior to this date, now raged in Ireland." We have no account of the prevalence of this disease beyond the steppes of Russia, as details would be wanting in the countries between Russia and India; while we could hardly expect to meet with pleuro-pneumonia in India, it being, like ordinary inflammation of the lungs, an affection of cold rather than of warm climates. That atmospherical or local causes have some influence in its production, may be inferred from the fact, that this disease and "eczema epizootica" appear to be only different forms of the same disease, for the one is sometimes found to terminate in the other. Referring to the prevalence of the foot-and-mouth disease, in 1841, in Ireland, Dr. Jackson remarks: "It was a pleuro-pneumonia to all intents and purposes, divisible into two stages—primary and secondary. In the first, there was ulceration of the feet, lining membrane of the mouth, nose, etc. . . . . In the secondary form of the distemper, we had inflammation of the pleura and lungs."*

The next epizootic that appeared was rinderpest, a foolish name, as it is merely the German for "cattle plague" —a term that will apply to any other bovine disease the same as this. Fortunately, we have more accurate accounts of this plague; and are, therefore, enabled to

* *Report of Cork Street Hospital.*

trace it from its first origin to its termination. It is stated, and has been repeated, *usque ad nauseam*, that the steppes of Russia are the home of rinderpest, although nothing can be more erroneous than such an opinion. We accuse the Russians of propagating the disease: they state that it was imported from Asia Minor, which means, that it prevailed there previously. This, no doubt, is the fact, for we have proof that it has prevailed in India since 1818—the year after the first appearance of the epidemic cholera—but there is no proof of its prevalence in Russia until 1828; being nearly coincident with the outbreak of cholera in that country. That rinderpest has prevailed in India from 1818 to the present time, there is abundant evidence to prove, as it appeared in Assam before its occupation by the British, in 1824. From the account given to Veterinary Surgeon Farrell, it appears, that a plague broke out in 1818, amongst the army cattle of the Burmese, who had invaded Assam. It destroyed them all, and spread into the country, committing great devastation. There was another visitation, in 1825, and a third, in 1830; but the particulars are wanting. Again, Dr. Gilchrist affirmed, that the *burra azar* of Madras is identical with *rinderpest*.* Colonel Campbell also states: "In 1849, plague attacked cattle at Tezpore, and so many died that it was impossible to remove them." Another visitation was experienced in Assam, in 1852-3, the loss being estimated by Mr. Grote, the Secretary to the Board of Revenue, at 120,000 cattle. It appeared again in 1854-5, since which it has prevailed, periodically, in the district. In 1860, deer, and other wild animals, were found dead in the jungle with the same pathological appearances. The Commissioners, appointed to inquire into the subject, state, that no doubt exists of its having

* *Practical Treatise*, 1848.

been *rinderpest*; and they add, "no case of recovery was heard of." Rinderpest broke out, also, among the cattle during a "cattle show," held in Calcutta, in 1864. Referring to this outbreak, Dr. Palmer remarks: "Sufficient has, we think, been advanced to prove the existence, very extensively throughout India, of two distinct and very fatal epizootics: the one we believe to be identical with the 'eczema epizootica,' or 'aphthous epizootic' or 'foot-and-mouth disease' of England: the other is identical with the Calcutta epizootic of 1864, or rinderpest."* Lastly, Mr. T. P. Gudgin, Veterinary Surgeon, 2nd Dragoon Guards, who witnessed an epizootic, that prevailed in Burmah in 1864-5, pronounces it to have been rinderpest; and he sets down the loss at 100,000, although the disease had not then terminated. Instead of the steppes of Russia being the home of rinderpest, it is the plains of India, if the place in which it first appears is to be called its home. It is impossible to trace its course from India to Russia, from the absence of information, and from the fact, that the prevalence of epizootics in those regions would have excited little attention in Europe at that time. But, that the cattle along the line of route taken by the epidemic cholera, through Asia Minor and Persia, were also attacked by disease; and that it prevailed there before it appeared in Russia, we may be certain, not only from the circumstance before mentioned,—viz., that the Russians consider rinderpest to have come from Asia,—but, also, because this disease has been the almost invariable accompaniment of the epidemic cholera in all other regions.† This conclusion would seem to be con-

* *Report to the Secretary of the Bengal Government*, 1871.

† It has been my object to show, in the chapter on Epizootics, that rinderpest, although considered to be a form of typhus, similar to that of the last pestilential epoch, has no analogy with

firmed by another circumstance. During the recent outbreaks of plague in Asia Minor and Persia, epizootics have prevailed at the same time. In fact, Dr. Rossi, inspector of quarantine at Erzeroom, attributed the manifestation of the plague at Maku—a town in the north-west of Persia, on the Turco-Persian frontier,—to the severe murrain that had prevailed previously. Unfortunately, the course of the disease from the south of Russia to England has been precisely that of the ordinary route of cattle, and this circumstance has afforded the contagionists one of their strongest arguments. But it does not hold good in other instances, for there is no importation of cattle into Asia Minor or into Russia; and yet, as we have seen, the disease sprung up in India many years before it appeared in Russia, and must, therefore, have passed across the intermediate regions. Then, again, rinderpest spread at the same time, in the opposite direction, or from west to east, for it has existed in China for many years; although from the want of communication with the interior of that country, its existence was not known until recently. It was first noticed at Shanghai in 1868, by Dr. Thin, who remarks in a letter addressed to the *North China Daily News*, that the disease was considered by the natives to be "Ma ping" (blood disease). It was, they added, of common occurrence. Dr. Henderson, who also observed the disease at the same time, states, in his report, that "he believes it to be as truly endemic (epidemic ?) in the great plain of China as in the steppes of Russia." * As this murrain is, like the epidemic cholera, a new disease—and, as remarked before,

that disease. It is merely a modified form of cholera. We need not be surprised, therefore, to find, that it has so constantly accompanied and followed the former disease.

* *Customs Gazette of Shanghai*, January to March, 1872.

distinct from the murrains that prevailed during the last pestilential epoch—we may presume that it sprung up in China, the same as in India, after the appearance of the epidemic cholera, which, as may be remembered, spread not only to the north, but also, by another line, to the south-east, as far as China. More than this, we may be certain that it sprang up there spontaneously, as no cattle are imported into China from India. It is thus evident, that epizootic diseases have sprung up simultaneously with those in the human race, have obeyed the same laws, and have progressed along the same well-defined and peculiar line of the earth's surface. There is only one exception to this rule: the rinderpest has not yet made its appearance in America. But it will do so, some day, in spite of quarantine, and the intervening sea, and for the simple reason, that the same morbific line has passed across that continent; as we have proof by the spread of the epidemic cholera, and by the appearance there of eczema epizootica, pleuro-pneumonia and influenza.

This progressiveness is not confined to great pestilences, like the preceding, and those reputed to be contagious: other diseases of a comparatively mild form, and universally allowed not to be infectious, exhibit the same phenomenon, and in a more marked degree. This is the case with influenza, which has preceded, accompanied or followed, all the great pestilences of which we have any record. The accounts respecting the exact course of this disease, during the first part of the late pestilential epoch, are necessarily meagre and imperfect; but in 1510, influenza spread from Malta to Sicily, Spain, France, Great Britain, and the north of Europe, thus pursuing, so far, the exact route of the plague or black death.* In all pro-

* This was the first recorded visitation of influenza in England; but, according to the "Annals of the Four Masters," it was epidemic in Ireland in the 14th century.

bability, it had spread previously from Asia to Europe, as was usually the case. Thus, the influenza of 1557 commenced in Asia, and then passed, with great rapidity, to Constantinople, and thence over Europe by the route already described. It also spread to the continent of America, the first notice we have of the prevalence of such a disease in that country. The next visitation, that of 1580, followed the same course, viz., from east to west, and from south to north. The same disease continued to return, from time to time, until the termination of the last pestilential epoch; eight visitations having been recorded by different writers during the last century—the first in 1709, and the last in 1782. There was a slight visitation in England in 1803; but no other until 1832, a year after the outbreak of cholera. It might be concluded, that this was the first visitation of influenza, of the present pestilential epoch; but I should be inclined to refer the influenza of 1782 to the present, not the past period, and for this reason—its route was different. Instead of proceeding from east to west, and from south to north, it pursued the opposite course, from its origin in China, viz., from south to north, and from east to west, having, after reaching Russia, passed through Denmark and Holland to England. It thus traversed precisely the same line as that subsequently pursued by the epidemic cholera, and all the general influenzas that have followed in its train. We may therefore infer, that the morbific line, previously described, had been formed some years before the first appearance of the epidemic cholera in Bengal, in 1817.

The next influenza that appeared was in 1830-31. Like the former, it commenced in China, having broken out on board the E. I. Co.'s ship Inglis, on the 25th January, 1830: on which day eight men were attacked, twenty-four on the 26th, ten on the following day, and six on the

28th. The disease, *within two hours*, was as severe as at any time during its continuance. The epidemic then spread across the continent of Asia to Russia, Germany, England, and France, where it arrived in the autumn of 1831, having thus taken rather more than a year to traverse the whole of the route. Horses were affected at the same time. In 1833, influenza, or *grippe* as it is termed in France, sprung up suddenly in Russia, and then spread through Poland, Germany, and Holland to England—men and horses being simultaneously attacked, the same as in the former visitation. Whole families were struck down suddenly, and whole populations in the course of a few days. At Memel, 8,000, out of a population of 10,000, were suffering at the same time. In St. Petersburg, there were, it was calculated, 100,000 persons attacked almost simultaneously, and 500,000, or about a fourth of the population in London. Some districts, in the line of route, were entirely spared, or only partially invaded.

Sometimes, influenza is confined to the brute creation, the same as other diseases.* This was the case in 1841, when influenza appeared in the north of Europe, and then spread through Bohemia, Prussia, Holland, England, France, Spain, and Portugal, attacking all the cattle on the line of its march, with almost railroad rapidity. A more recent example has been afforded, by what has been termed the American Horse Distemper, or influenza. It first appeared at Toronto, on the 20th

* "Cows and horses have especially suffered from influenza, as was observed in the epidemics of 1733–37, and –43. Dogs, cats, deer, sheep, and swine, have not enjoyed any immunity; poultry, also, and even fish, seemed occasionally to be affected by the morbid influence."†

† *Annals of Influenza.* By Dr. Theophilus Thompson. London. 1852. P. 375.

September, 1872, and then spread to Buffalo, Rochester, and other towns on the Canadian frontier. From this point it passed, in a southerly direction, through the eastern States of North America—Boston, Jersey City, New York, Keene, Philadelphia, Chicago, Washington, Oswego, and Baltimore being attacked in rapid succession. It reached Galveston, Texas, and Pensecola (Florida) the end of November, thus taking two months to traverse the line from Toronto, in Canada, to the southern part of the United States. This is a longer time than influenzas generally take to spread over a similar extent of country, which may be accounted for, perhaps, by the peculiarity of the disease. Dr. Fricke concluded, that the epidemic was more virulent than ordinary influenzas, and, from the anatomical lesions presented after death, that it is closely allied to the epidemics of diphtheria in the human subject.* The writer adds that, out of 30,000 horses in Philadelphia, above 2,250 died in the course of three weeks. No horse, it is stated, on the line of march of the malady, whether in town or in country, escaped. In order to show how this disease, like others, pursues its own peculiar course, irrespective of accidental circumstances or human intercourse, we may refer to the influenza that appeared in 1837. As may be remembered, the epidemic cholera spread from England to France, Portugal, Spain and Italy, being the reverse course to that pursued by the black death or plague. This was the case, also, with the influenza just referred to. In January, it appeared on board the ships of war at Sheerness; in February, in the ships and in the towns on the north coast of Spain; in March, on the south coast of Spain; in April, at Gibraltar; and in May, at Malta and in the English Mediterranean fleet.† It thus pursued the oppo-

* *Philadelphia Medical Times.*

† *Statistical Report of the Royal Navy*, 1837—43.

site course to that taken by the influenzas and other diseases of the last pestilential epoch.

LAW II. ANOTHER LAW, CHARACTERISTIC OF THESE DIFFERENT PHENOMENA, IS THE REGULARITY OF THEIR PROGRESS, BOTH CHRONOLOGICALLY AND GEOGRAPHICALLY.

Although this rule is not so evident with regard to the formation of volcanic vents, on account of the want of historical data, in such instances, their production being frequently the work of ages, it is yet sufficiently clear to cause it to be set down as one of the laws of volcanic action; the vents along a particular line not being formed at once, but in succession. It is, however, from the minor effects of the same cause, that we have the best evidence of the progressiveness of volcanic action. Thus, earthquakes are sometimes observed to commence in one particular spot, and then to extend, regularly and slowly, over some considerable portion of the earth's sphere. A memorable example of this was afforded at the time of the appearance of the black death; when severe and remarkable concussions of the earth occurred in China, and thence extended through Asia Minor to Europe. It is only at a certain epoch, however, that this phenomenon is observed: at a later period of the volcanic process, earthquakes occur at particular, although, sometimes, extensive, points of the volcanic line; and sometimes at one point, sometimes at another.

With respect to diseases, the regularity of their progress is such, that their appearance, in a particular spot, has been predicted with accuracy long before the expected period. Thus Dr. Hecker, narrating the particulars of the breaking out of the black death in different parts of Europe, remarks: "The precise days of its irruption in the individual towns are no longer to be ascertained; *but* *it was not simultaneous*; for in Florence the disease appeared in the beginning of April; in Cessena, the 1st of June; *and place after place* was attacked throughout the whole year: so that the plague, after it had passed through the whole of France and Germany (where, however, it did not make its appearance until the following year), did not break out till August in England; where it advanced so gradually, that a period of three months elapsed before it reached London. The northern kingdoms were not attacked until 1349—almost two years after its irruption in Avignon; and in Russia it did not make its appearance until 1351—more than three years after it had broken out in Constantinople." (*Loc. cit.*, p. 50.)

The same law has been found to hold good with respect to the epidemic cholera, for it progressed with great regularity from the peninsula of India to the shores of America. In consequence, however, of the numerous observations, that have been collected from different quarters of the globe during the prevalence of this disease, we are enabled to add, what was not before ascertained or noted, in all probability, viz.,—that although its rate of progression was exceedingly regular in a particular country, or region, it has varied much in different situations. Thus, after leaving the Delta of the Ganges, its rate of travelling was very uniform across the whole of the peninsula of India,—along the northern coast it was about a degree a month. But, although it only took a year to traverse the distance from Calcutta to Bombay, it was seven years extending from the southern part of Persia to the northern shores of the Caspian Sea, through the mountainous regions of the Caucasus; while, in Russia, it traversed the immense distance of 700 leagues, from the borders of the Caspian Sea to the shores of the Baltic, in the short space of six months. Notwithstanding this difference in different localities, its rate of progression, in the same country, or district, and in different countries, *characterized by the same geological features,* was singularly uniform; of which any one may convince himself by referring to the date of its arrival in each successive town, in the various portions of the globe visited by the disease. Moreau de Jonnes states that, in 1832, the degree of rapidity with which the disease spread in different directions, in France, was as follows. "Cholera appeared in Calais on the 15th March, 1832, and broke out at Arles on the 17th September following; having thus, in 186 days, traversed 200 leagues, forming the great diameter of France from north to south. The disease was recognised in Paris on the 24th March, 8 days after its appearance at Calais. On the 27th April, it had spread, by contiguity, to the Department of the Moselle; and, on the 11th May, to that of Finisterre, taking 35 days to reach the eastern, and 50 days to reach the western frontier of France;—having traversed, on the one side, 70 leagues, and, on the other, 120. Thus, the cholera traversed the territory of the kingdom (of France) from north to south *at the rate of one league in* 24 *hours;* whilst, from east to west, it required but 85 days to travel a distance of 190 leagues; which gives a rapidity of speed greater by one half."* It is also evident, from what has gone before, that the rate of travelling of influenza is nearly the same, not only during different visitations at the same period, but, also, at different and distant epochs.

The same law is apparent with the diseases of the brute creation. The memorable murrain of the 17th century, which has been described by Dr. Winklan, commenced on the borders of Asia, and then travelled, slowly and regularly, across the Continent of Europe, from east to west. Its rate of travelling was 14 *miles an hour,* and country

* *Lancet.* Vol. 1, 1832-3, p. 698.

after country, and district after district, were attacked in succession—the disease never appearing in very distant places at the same time, or continuing its ravages in one spot beyond a certain period. No cattle on *the line* of its march escaped: those that were within doors fell ill at the same time, and in the same manner, as those in the open fields. Yet the lateral boundaries of the disease were well defined and very limited.*

But, what is still more singular, is the fact, that the rate of progression of a particular epidemic, along the same line, or portion of a line, is nearly the same at different visitations. This is shown in the following Table.

TABLE B.—*Date of the appearance of Cholera, at the under-mentioned places, at two different periods.*

	1832	1834
Quebec	8th June	7th June
Montreal (180 miles from Quebec) ...	10th "	11th "
Kingston (190 miles from Montreal) ...	16th "	26th "
Toronto (184 miles from Kingston) ...	28th "	30th "

Here, there was a variation of *three* days only, in a march of between 500 and 600 miles.—Accident could not have produced such a result: while the stream of human intercourse is never so regular and so unvarying. This is more particularly apparent in the following instance. Dr. Cunningham, referring to the spread of cholera in India, states, that the epidemic does not travel more rapidly since the railways have been constructed than it did before, notwithstanding the difference in the rate of travelling of the population. Thus, the epidemic, in 1861, commenced in Cawnpore in May, and reached Meean Meer on the 2nd Aug. It broke out again, in 1872, in the same town, and in *the*

* *Philos. Trans.* Vol. 13, p. 93, A.D. 1683.

same month, and reached Meean Meer on the 31st July, a difference of only two days.*

There is another circumstance well worthy of attention, in considering the rate of progression of these different diseases; this is, that their progress along the whole track pursued by them, although varying so much in different situations, appears to be about the same, when different epidemics are compared together. Thus, the black death took 14 years to reach the confines of Europe, having commenced in China in the year 1333, and having broken out in Constantinople in 1347. From this point it gradually spread, by the route before described, to the northern parts of Europe, which it reached in 1351, or four years after its appearance in Constantinople. Now it so happens, that the epidemic cholera was exactly 12 years travelling from the extremity of India to the confines of Europe; having commenced in Bengal in the year 1817, and having broken out in Astrakan in 1829; it did not spread, however, beyond this locality until the following year. Although the disease from this point pursued a different route to that taken by the black death—as it visited the northern kingdoms of Europe first, and the southern last—it is a remarkable fact, that this epidemic took about the same time to perform this circuit that the former did to complete the other route; for the cholera appeared in the countries bordering on the Mediterranean five years after its commencement in Astrakan, on the borders of the Caspian Sea—a difference of only one year. Such facts would be perfect anomalies, and altogether inexplicable, when viewed by the doctrine of contagion, as no reason can possibly be given, why the disease should have been propagated as speedily in the one case as in the other; for the commercial traffic and inter-

* *Ninth Report of the Sanitary Commissioner for India*, p. 16.

course, in the whole of these countries, must have been widely different in the 14th and in the 19th centuries; independently of the fact, that the routes are not the same, or the intercourse either, for the commercial traffic between the South of Europe and Constantinople and Egypt was altogether insignificant in the 14th century. And yet, although this traffic is now so great and so constant, the epidemic cholera invaded Europe by a route along which there is scarcely any traffic or commercial intercourse.

LAW III. The next law, regulating subterranean action, is, that its effects are greater on tertiary than on secondary strata; while they are seldom witnessed on primary formations.

Thus, the most common effect of volcanic action, the earthquake, occurs in general on tertiary formations, while the shocks are felt more severely in the deltas, and alluvial tracts at the mouths of rivers. It is also observed on secondary formations: but its effects are then more limited; while, on primary formations, concussions are slight, and almost unknown. The more rare effect of this action, viz., the volcano, is, on the contrary, generally observed on secondary strata; and is seldom found either on tertiary or primary formations; there being only one exception to this rule, viz., the volcanos of Chili.

The same law applies, with equal force, to the march of epidemic diseases. Like the effects of subterranean action, they are most prevalent on tertiary formations, less so on secondary strata, and very rare on primary formations. According to M. Lombard, the plague has never appeared at an elevation above 600 metres: and he cites the instance of Alem-Daghi, a village near to Constantinople, situated 500 metres above the level of the sea; to which place the inhabitants of this city are in the habit of flying, during visitations of the plague—some of them with the disease upon them—yet it never spreads.* There are, also, other situations, as those near to *Safi*, in the island of Malta, and the citadel at Cairo, which have hitherto been exempt from the plague. The same law is apparent with respect to the prevalence and spread of yellow fever. Humboldt remarked, long since, that yellow fever, although so prevalent in the plains below, is unknown in the city of Mexico, situated at an elevation of 5,000 feet. The limit of its range is, however, much less than this. "Dr. Toner, President of the American Medical Association, Washington, has contributed a paper on the distribution of yellow fever, which is published in a report issued by Dr. Woodworth, Supervising Surgeon of the United States Marine Hospital Service. Dr. Toner quotes authorities which show, that this disease has never been known in any climate at an elevation of 2,500 feet. Mount Desmoulin, near Rousseau, in the Island of Dominica, 1,500 feet above the sea, is always free from fever, even when it is epidemic at the water-line. The same exemption is observed in the northern and elevated parts of San Domingo, whatever may be the character of the soil. Fort Smith, in Arkansas, 460 feet above the sea, is the highest point at which this fever has prevailed as an epidemic in the United States. Although Winchester, Virginia, at an altitude of 700 feet, is reported to have been visited by this disease, in 1802, the cases recorded are not well authenticated. The late Dr. La Roche, noticed that a stranger might live securely in the near vicinity of the epidemic, provided he did not actually enter the infected district. It is clear, that the disease has, in the United States, never, in an epidemic form, reached an elevation of 500 feet." † In the West Indies, its range is greater,

* *Les Climats des Montagnes.*

† *The Medical Times and Gazette*, May 16, 1874.

having been observed at Newcastle, Jamaica, and other localities, situated at an elevation of between 1,000 and 2,000 feet. But it never prevails in a very severe form in such localities, while the disease is always limited in its range. Like the plague, yellow fever, when imported, does not spread in such situations. Dr. Smith states, that, "when persons infected with this (yellow) fever arrived in the city of Arequipa (7,850 feet high) from the sea-port Islay, many of them died with black vomit; but, in each separate case, the germ of the disease seemed to have died with the individual." *

Numerous examples of the same kind have been afforded during the prevalence of the epidemic cholera. We are informed by Dr. Henderson, that the 19th Regiment of Infantry, to which he was attached, together with the 38th and 48th, encamped on a low marshy spot, near to Patnago, in 1825: in the morning, one officer was attacked with cholera, and, in twenty-four hours, twenty men were carried off. On the following day, the corps removed to a higher ground, a mile and a half off: and, from this time, no more cases of cholera were observed. Another example, but on a larger scale, was afforded by the army of the Marquis of Hastings, which was attacked with cholera in Bundlekund, during the first year of the prevalence of the epidemic. This division of the grand army had encamped on the banks of the Scinde, immediately after which the epidemic appeared: commencing, in its usual insidious manner, by attacking only the lowest orders of the camp-followers. But, in a few days, and as it were in an instant, the disease burst forth with irresistible violence. "Unsubjected to the laws of contact, and proximity of situation," to quote the language of the Bengal Report,

* *The Dublin Quarterly Journal of Medical Science*, May, 1866, p. 348.

"which have been observed to mark and retard the course of other pestilences; it surpassed the plague in the width of its range, and outstripped the most fatal disease, hitherto seen, in the destructive rapidity of its progress. In the course of a week, it had overspread every part of the camp, sparing neither age nor sex, in the undistinguishing virulence of its attacks—the old and the young, the European and the native, fighting-men and camp-followers, were alike subjected to its visits; and all sunk, in a few hours, under its most powerful grasp. It was then wisely resolved, by the commander-in-chief, to change the encampment, in search of a purer air, and a healthier soil: and although the line of march was covered with the dead and the dying—men dropping from their horses, or falling while marching in the ranks, as if struck by a cannon-ball—they succeeded, after a few intermediate halts, in reaching on the 19th, the high and dry banks of the Betwah, at Erich; where they *almost immediately got rid of the disease*, for not a severe case occurred after the 22nd." Now, although it must be confessed, that many of the mountainous tracts, which then escaped, have since been ravaged by the disease, yet it might be seen, even in these instances, as Mr. Jameson remarks, that high lands were not congenial to it; for the epidemic was generally raging with great violence on the plains below, at the very time that the hilly and mountainous tracts were only slightly affected by the malady. Although the cholera subsequently ascended to some of the highest inhabited ranges of the Himalaya mountains, the outbreaks have been few in number, and the disease limited in its range. "Kussowlie, in the Himalaya range," says Dr. Cunningham, "is only nine miles from the plains, with which there is constant communication; and yet, for the twenty-eight years, from 1845 to 1872, there is no record of any outbreak of cholera at Kussowlie. With the exception of 1867, when the disease was chiefly confined to the native servants, the oldest inhabitant cannot remember the occurrence of cholera at Simla, excepting in a few isolated cases; and, with these, the disease was imbibed in another locality (*Loc. cit.*) But, although ascending this primitive range, the epidemic was never able to cross this barrier; as it was by another and a different route that this *nova pestis* reached Asia Minor and Europe.* The greater prevalence of these diseases on tertiary strata, in alluvial tracts, and on the deltas of rivers, is so generally and so well known, that writers of various and different opinions have ascribed the origin of these complaints to malaria, or some other poison, generated in such situations; being afterwards propagated by particular channels or certain means, as contagion, to other and distant parts of the globe. But such a conclusion, for the reasons already given, will not hold good, while it is negatived by the fact, that the removal of the sick and the healthy to more elevated situations has generally been found sufficient to arrest the progress of the disease; and this too when intercommunion between the sick, or the refugees, and the residents was free and uninterrupted.

With regard to the difference, which the disease exhibited in different localities, we may refer for an example, on a large scale, to the mountainous regions of Persia and the Caucasus, and the vast plains and alluvial districts of Russia. It was in 1821, that the disease first attacked the towns situated on both sides of the Persian Gulf, whence it spread, slowly and gradually, by the route already mentioned to the southern shores of the Caspian Sea; which it reached in 1823. But there was a striking diminution in

* See Map 1, in Appendix.

the velocity, as well as in the extension of the malady, as it proceeded northward, and gained the defiles, and mountainous tracts, of the Caucasus, having taken seven years to traverse this region, proceeding step by step, and year by year, from one extremity of the mountain range to the other. This circumstance cannot be ascribed to the paucity of the inhabitants in these districts, for the malady extended, at the same time, to the large and populous town of Astrakan, where the visitation was as circumscribed, and subsided as quickly, as in other and more thinly inhabited regions. The malady continued to prevail every summer, to a slight extent, in the north of Persia, and on the southern borders of the Caspian Sea, until the year 1830: when, having apparently gained fresh strength, it suddenly extended in a northerly direction, and a second time attacked Astrakan. After cutting off 4,000 persons in the town, and 21,000 in the province, the epidemic proceeded with unprecedented velocity through the heart of the Russian dominions, committing great havoc among all classes of the natives, *in the thinly inhabited districts* as well as in the most populous. In the spring of the following year, it again re-appeared, and then spread through Poland and Germany with inconceivable rapidity; having reached Berlin in August, and Hamburg in October.

By a reference to any geological map of Europe—as that in the *Encyclopædia Metropolitana*—it will be seen, that the tract of country traversed by the epidemic, with such rapidity, forms one single and immense tertiary deposit; being bounded to the west and south by a chain of primary mountains through a great part of its extent. This barrier, here as elsewhere, was sufficient to prevent the spread of the disease in that direction; for although extending along the whole of this plain from south to north, the disease was not seen on the western side of this range of mountains. One exception occurs to the above, and this is the kingdom of Austria, which is situated to the west of these mountains. But, then, it will be seen, that the district thus referred to is not situated on primary formations; as a tract of country, extending from the Black Sea as far as Vienna—and which is somewhat broad at the base, or to the east, and narrow at the apex, or towards the west—is marked in the map as tertiary. Now it was precisely over this tract of country that the disease spread; for the epidemic, after reaching the borders of the Caspian Sea, proceeded in two different directions—one by the route before described, and another by the northern borders of the Black Sea, to the mouth of the Danube, along whose banks it extended as high up as Vienna. But, although the disease had thus reached the boundaries of Switzerland, this country continued free, for the epidemic did not spread any further in this direction. Switzerland, it is true, although spared during the first visitations of the cholera in Europe, has since been invaded by the disease; but it was in another and the opposite direction, by the opening on the western side of the mountains, and by the extension of the disease through the alluvial plains of France. Even this was not effected, until after the lapse of many years: while "the small mortality," as M. Lombard remarks, "which occurred, authorize us in concluding, that elevated plains and mountainous regions are not favourable to the development of the epidemic cholera." (*Loc. cit.*) Nothing can show the influence of locality, on the propagation of epidemic diseases, more forcibly than these facts.

The same law will be found to hold good with respect to the diseases of the brute creation. De Berg states, that the epidemic murrain of the last pestilential epoch was more prevalent in the lowlands than in the highlands:*—an exemption that was remarked in England, during the severe epizootic of 1745—57; the whole of Wales, with the exception of Montgomeryshire, having escaped the ravages of the disease. According to Haubner, the "trembling disease" of sheep prevails principally in low, damp, alluvial soils, and in valleys surrounded with mountains. Although the flocks have been renewed again and again, the disease has continued to return; and has only been arrested by the removal of the flocks to other and higher regions. Rot is another disease peculiar to low plains, being seldom met with in elevated regions; and the same may be said of ovine small-pox. This law has been, if not better observed, more clearly demonstrated during the prevalence of the present epizootic, or rinderpest. Not only did it commence in the low, alluvial plains of Russia, on its first appearance in Europe, but it has continued to prevail there and in similar situations—not exclusively but principally—up to the present time. Thus, it spread, at an early period, to the south of the Carpathian mountains, over the tertiary formation before referred to, on which Austria, Hungary and Moldavia are situated. But it was unable to pass the mountains of Switzerland, the Tyrol and Upper Moravia, which thus appeared to stand like a wall between the disease and western Europe. So, again, it has never penetrated the mountainous regions of the Balkan, or prevailed to any extent in the elevated districts of Transylvania—from 2,000 to 8,000 feet above the level of the sea—or in those of Servia, Bosnia, and Bulgaria. It was by a different route, that the cattle plague reached the western part of Europe; by the alluvial plains of Russia, of Poland, Podolia, Wallachia, Silesia, Holland, and France—thus making a complete circuit before arriving

* *Mémoire sur le Typhus*, 1776.

at the western frontier of Switzerland, into which it penetrated in 1872—forty years after it had appeared on the eastern side of the Swiss mountains.* It re-appeared in 1873, and committed considerable ravages; but the disease was confined to the lowlands. It is also worthy of remark, that Prussia, and the more elevated regions of Germany, although surrounded by the plague for many years, escaped the disease—or, at least, a serious visitation of it—until 1871. According to Renault, the steppe cattle remain exempt from rinderpest in the Upper Palatinate, and in Swabia: and other writers affirm, that it never prevails at an elevation above 500 feet. There are, however, exceptions to this; but the limitation of range of the disease is then very marked and slight.

We have observed the same results in England, it having been precisely on the low, alluvial, plains of Cheshire, Cambridgeshire, Huntingdonshire, etc., that the cattle plague committed its greatest ravages. On the other hand, there was not, with the exception of Denbighshire and Flintshire—the geological formation of which is somewhat different to that of the other eight counties—a single case on the primary mountains of Wales. But the ravages of the disease, in these two counties, were altogether insignificant, when compared with those on the plains below. This will be evident by a reference to the following Table.

TABLE C.—*Showing the number of cattle, that were attacked and died, in the following counties, in* 1865-6.

Counties	Total Cattle	Number attacked	Ditto killed	Died	Recovered	Healthy cattle killed
Cheshire ...	137,798†	93,376	38,618	40,851	13,907	4,690
Flintshire	36,080†	9,020	1,261	6,567	1,192	326
Denbighshi'e	46,695†	4,279	180	3,487	608	395

* This, as will be evident, from what has gone before, is precisely the route that was taken by the epidemic cholera.

† These were the numbers on the 5th March, 1866.

It will thus be seen, that 67 per cent. of the cattle were attacked in Cheshire; while in Flintshire, according to the official returns, only 25 per cent. were attacked, and only 9 per cent. in Denbighshire. This result cannot be ascribed to the preventive measures adopted, for the pole-axe was used less freely in Wales than in Cheshire. In the latter county, 41 per cent. of the cattle attacked were slaughtered; in Flintshire, 13 per cent., and, in Denbighshire, only 4 per cent. And yet it was precisely in the last-named county, that the course of the disease, in this direction, was arrested. The county of Westmoreland, also, which, like Wales, is formed of Silurian rocks, remained almost entirely exempt, although actually hemmed in by the disease. In Scotland, the counties of Bute, Argyle, Banff, Elgin, Nairn, Ross, Cromarty, Sutherland, and Caithness — mostly situated on primary formations — escaped altogether, as, also, Orkney and the Shetland Isles. That these exemptions are to be referred to geological formation only, will be evident by a reference to the Table now added.

TABLE D.—*Showing the number of isolated outbreaks of cattle plague, in England and Wales, arranged according to geological formations.**

Tertiary and post-tertiary formations	952
Chalk formations	400
Oolite „	268
Lias „	102
New red marl and sandstones	663
Magnesian limestone and Permian marl	120
Coal measures	402
Old red sandstone (Devonian)	59
Silurian	6
Cambrian rocks	0
Metamorphic rocks, quartz, etc.	12
Igneous rocks	5
Total	2,989

* *Report of the Veterinary Department of the Privy Council.* By A. W. Williams, L.R.C.P. (Ed.), M.R.C.S. (L). 1866.

Even when the disease does appear in mountainous regions, it will be found to prevail, less and less, the higher we ascend. Thus, its prevalence in Yorkshire was in an inverse ratio with the elevation; while it disappeared altogether at the height of 1,000 feet. "In Yorkshire, 2,000 farms were attacked, but as many of these were near to each other, the 'centres of infection' were only reckoned at 680. Of this number, 538 or 79.11 per cent. have occurred at an altitude not exceeding 250 feet: 98 or 14.41 per cent., at an altitude not exceeding 500 feet; 39 or 5.73 per cent., at one not exceeding 750 feet; 5 or .73 per cent., between that height and 1,000 feet; no case having occurred above this height." (*Loc. cit.*, p. 35.) The uplands of Wiltshire also escaped almost entirely—an exemption that occurred during the severe epizootic of 1745-57.*

Although usually exempt, epidemic diseases do occasionally break out, and prevail generally, in elevated and mountainous districts; in which case, the disease almost invariably presents a more severe and fatal form. It is the same with epizootics. This has been remarked by Veith, who says that the cattle plague does occasionally break out in hilly districts, and that it is then more deadly.† Ampach also states, that he has observed this

* Notwithstanding these exemptions, and in localities actually surrounded by the disease, we have been told by the contagionists, that the poison of cattle plague can not only be carried by birds and other animate things, from place to place, but even by the shoes and the stick of a pedestrian from John o'Groat's to Land's End! When will men cease to feign hypotheses, and learn to search for facts? At the commencement of the cattle plague, I published a *brochure*, and suggested that the animals, when attacked, should be removed to elevated situations. The veterinarians, however, rushed in with the pole-axe, and removed them, not to more healthy localities, but to a place where worms do grow, and flesh becomes corrupt!

† *Handbuch der Veterinärkunde.*

disease in mountainous districts; and that the disease was then, not only more active but, also, more rapid in its course.* The cause of the variation, or exception, will be better understood hereafter.

LAW IV. ANOTHER LAW TO BE MENTIONED IS, THAT THE EFFECTS OF VOLCANIC ACTION ARE ALWAYS MUCH GREATER, AND MORE PERCEPTIBLE, NEAR THE SEA, LAKES, RIVERS, SPRINGS, ETC.

Thus, the volcano is never witnessed except near the sea, or great inland collection of water. Even those volcanos which lie inland, says Lyell, form part of a chain of volcanic hills, and may be supposed to have a subterraneous communication with the extremities of the chain, or with those volcanos which are near the sea, or large masses of salt water. The neighbourhood of the sea, therefore, seems to be one of the conditions necessary for the ascent of lava to great heights. Again: Whenever an earthquake, for the volcano is entirely a local phenomenon, is experienced, the shocks are always more perceptible in the sea, in lakes, and springs, than on dry land, being frequently observed in the former when no effect has been perceptible in the latter. A memorable example of this was afforded during the great earthquake, which occurred at Lisbon in the latter part of the last century, when a wave was produced, that extended to the shores of England and Holland, as well as other places farther removed from the centre of concussion. But independently of this effect in the waters of the ocean, which can be readily accounted for when it is known, that a wave 60 feet high rose at Lisbon, similar disturbances were felt in the water of lakes, canals, and ponds, both in Holland and England,—situations altogether removed from any, or the least, communication with the sea. Thus,

* *Praktische Lehre von den Heerde Krankheiten*, etc. Pesth, 1819.

on the day when the above earthquake occurred, a surprising and frightful noise was heard at Bilborough, in Derbyshire, near a large body of water called Pilby Dam; and a swell, which came in a current from the south, rose two feet on the north side of the lake. At Loch Lomond, in Scotland, the water, without the least apparent cause, suddenly rose against the banks to some considerable height, and then as suddenly subsided far below its usual level. At Eaton Bridge, Kent, the water of a pond was observed to open in the middle, so that a post, *before covered with water*, could be seen a great way down, almost to the bottom. The same or similar phenomena occurred in many parts of England, and in various parts of the continent, even in the north of Germany, although the concussion itself did not extend far to the northward of Lisbon.

So frequently do epidemics make their appearance at the mouth of some river, and so invariably are they propagated along the banks of those streams, at whose mouths they appear, that this circumstance has afforded the advocates of the doctrine of contagion one of their strongest arguments; as it is generally in the course of rivers that commercial traffic and human intercoure are the greatest and the most regular. Thus, the epidemic cholera first broke out on the banks of the Ganges, and ascended by the course of this stream, for 400 leagues, to the interior of India. It then attacked all the towns situated on the Jumna; and, from Allahabad, at the confluence of this river and the Ganges, it spread to the districts watered by the tributaries of these streams. Subsequently, it followed the course of the Bourrampooter, the Gogro, the Chamboul, Beteva, and the Sinde Rivers. So, also, when it commenced its ravages on another continent, it proceeded, after attacking the towns on the borders of the Persian

Gulf, by one route, slowly, and with apparent difficulty, through the arid tracts and mountainous regions of Persia, as far as the Caspian Sea; while it proceeded, by another route, with the greatest rapidity, along the banks of the Euphrates and Tigris to the Mediterranean. Again; when the disease reached Astrakan, it spread with unprecedented violence along the banks of the Volga, until it reached Moscow on the one hand and St. Petersburg on the other: traversing a distance of 550 leagues in little more than two months. Its progress was equally rapid on the Don: and no less so on the banks of the Dneiper: while it was along the banks of the Danube, that the epidemic proceeded towards Vienna, and ascended to the rest of the Austrian dominions. In England, also, the first cases that occurred were on the banks of the Tyne, the Humber, and the Thames. Precisely the same law was found to hold good in America. "It was in June 1832," as we are informed by one writer, "that Asiatic cholera first made its appearance on the north-east coast of America, and spread, with fatal rapidity, along the great water courses on our northern frontier. Whilst one branch of the epidemic passed down the Hudson to New York, another continued west along the great lakes, until, in September, it reached some of our military posts on the Upper Mississippi. General Macomb says, that the cholera infected the troops on board the steamboats on their passage up the lakes: and such was the rapidity with which this disease spread among them, that, in a few days, the whole of the force sent by the lakes—to attack the Indians—was rendered incapable of taking the field. The loss by cholera, in that detachment alone, was equal to one out of every three men."*

It is worthy of observation, as showing the local origin

* *American Journal of the Medical Sciences.* April, 1842.

of these diseases that, although prevailing most in tertiary formations, and although extending with greater rapidity in the course of rivers than in any other direction, they have not always commenced at the mouth of these streams, or, at the point to which commerce and traffic happen to verge in that particular locality; notwithstanding that these situations were in the direct route, which the disease was pursuing, and notwithstanding that the towns, at first passed, were subsequently attacked. Thus, the plague of A.D. 252 began in Ethiopia, on the borders of Upper Egypt; Lower Egypt, and the towns on the sea coast, being subsequently attacked. The same result was observed in 1736. The plague of 1348, also, as well as that of 1482, appeared first at Avignon, and afterwards at the ports and towns on the Southern Coast of France—the course of the disease being, not from north to south, but from south to north. Again: the first case that occurred in England was not at Sunderland, or any other part of the coast, but at some distance in the interior; while the individual, it was proved, could have had no communication with persons coming from an infected spot. So, also, when the disease reached Russia in 1829, instead of commencing, as we should have concluded it would, in Astrakan, a large and populous town on the sea coast, it broke out at Orenburgh, situated on the banks of the Ural, 400 *miles* north of the Caspian. A similar phenomenon occurred in 1869, the cholera having broken out at Kïev, 200 miles inland, while Odessa, the port to which all the steamboats, on the Black Sea, converge, was not attacked until six months after. Every attempt to prove the importation of the disease into these places having failed, we must conclude, that when the malady reaches any alluvial tract, it selects that town, the situation of which is most exposed, and the best fitted, to receive the impression of the pestilential virus; no matter whether it be at the mouth of a river, or whether it be in daily communication with other and previously infected districts. The same result was observed with the cattle plague, which commenced in London, on the banks of the Thames, not on the coast, or at the places of disembarkation.

Next to the alluvial tracts and banks of rivers, epidemics have always prevailed most near inland collections of water, as lakes, ponds, etc., while their greater prevalence in the neighbourhood of particular springs, when compared to other situations, has doubtless given rise to the popular opinion so frequently, and we may say generally, entertained, during the prevalence of every epidemic, that such waters had been rendered deleterious by human agency.

LAW V. The last law common to these different phenomena, which we shall now consider, is their limited duration; their periodical return; and their total cessation, in that particular locality, after certain definite periods.

Thus, volcanos only throw out lava for a certain period, as a few days, weeks, or months, although the minor products of the same process, or aqueous vapour and gaseous substances, continue to be evolved for a much longer time, as several years. When, however, a vent has been once formed in any locality, eruptions are sure to be experienced from time to time, in the same spot, although the period of their return varies much in different situations. The same circumstance is observed with regard to earthquakes, except that they return more frequently, and at shorter intervals, than the eruptions of volcanos; for although the duration of a single shock is seldom more than a few minutes, still, a succession of shocks is sometimes felt, in the same spot, for many weeks or even months. They then subside entirely, for a period which varies under different circumstances, when they again return, and again subside, to re-appear after another interval; for *the same continuous tracts*, as Lyell justly observes, are agitated again and again. In some situations, they are found to return at regular and fixed periods, or months in the year, more particularly in the summer season. When, however, these effects have continued for a certain period, —and, generally, a long period, many centuries—they are found to cease entirely in the district, or part of the globe, where they have been observed. It has been this circumstance, which has caused volcanos to be divided into active and extinct; or, those which are subject to occasional eruptions, and those which have not been observed to throw out lava or gaseous matter, during historical periods. Numerous groups of the latter are scattered over the earth's surface the same as the former; in which situations, not only does the volcano remain in a quiescent state, but concussions and other signs of volcanic action are also wanting. This may be received as a proof, that the volcanic process is not permanent; but that it has its rise, fall, and total cessation, in each district, or spot, where it has prevailed.

The same phenomenon is characteristic of epidemic diseases, as they seldom prevail during one irruption for more than a few months—sometimes for only a few weeks or a few days—although we witness returns of these diseases for many years—generally for centuries—at regular or irregular periods. Thus, the plague, or, as it was afterwards termed, the black death, broke out in the middle of the 6th century, continued to return at certain periods, and prevailed extensively in Europe, until the end of the 17th century. It then ceased, excepting in a few instances in the south of France, and in Russia, and in Turkey and Egypt, in which countries it will also cease, we have a right to assume, at no very distant epoch: unless plague, in common with other diseases, should again return, the new morbific line having crossed these countries also, although in a different direction. The epidemic cholera has followed the same law, excepting that we have, as yet, only witnessed its rise, not its decline or disappearance. Like the plague, it has continued to devastate the same tracts over which it first passed; while the period of its stay, at each visitation, would appear to have been about the same. According to M. Moreau de Jonnés, the longest period during which the epidemic cholera has continued in any particular town, or locality, is 114 days, and the shortest 20. But its duration was even less than this in the east; in the upper provinces of India it seldom remained in a town or district more than 10 or 15 days. What the duration was of the black death in the east, we have no accounts; but, in the west, it seems to have remained during each visitation about the same period as the epidemic cholera, or, from 2 to 3 months.

The intervals, between the visitations of epidemic diseases, are generally shorter and more regular than the ordinary effects of volcanic action. The great pestilences would appear to return about every 10 years. This was near the interval of the appearance of the plague in Europe, in Asia, and in Egypt. Thus, there was a visitation of plague in Egypt in 1815, 1825, and 1835. The cholera years in England have been 1832—48,—54, and —66—the intervals being 16, 6 and 12 years.

Having thus shown, that the laws, which regulate the effects resulting from volcanic action, as manifested on the crust of the globe, and those which govern the duration and progress of pestilential, or epidemic, diseases, are similar, it follows, either that these various phenomena arise from two different causes, governed by the same laws; that the one set is an effect of the operation of the other; or, lastly, that they are common effects of a common cause. When we remark, however, that these effects are so various and dissimilar, it is difficult to conceive, how different causes could give rise to phenomena which, varying both in kind and degree, should observe exactly the same laws. That, on the other hand, the one set of phenomena is the cause of the production of the other, we might, at first sight, be induced to infer from the remarkable fact, that epidemic diseases seldom prevail to any extent, or for any long period, without being accompanied by concussions of the earth. This circumstance has been particularly dwelt on by Noah Webster, who, in his *History of Epidemics,* says; "It has been ascertained, beyond all question, that the periods of extensive pestilence and mortality are remarkable for earthquakes and eruptions of volcanos. But the explosions," he adds, "do not so generally precede epidemics, as to authorize the supposition that they produce these diseases. Earthquakes occur during the prevalence of pestilential or other mortal epidemics, but generally in the midst of the period, sometimes at the conclusion." In fact, it more frequently happens, that the concussion occurs on the termination of the epidemic than at any other period—a circumstance that has been remarked by many writers. Thus Van Swietan says; "When the plague raged at Ockazon, on the very day the distemper began to abate a violent earthquake happened;" and he, at the same time, asks, "Did anything exhale from the earthquake antidotal to the contagion of the plague?"* Independently of the above, it does not always happen that earthquakes occur

* *Commentaries,* vol. xvi. p. 36.

in the seat of pestilence, especially during the prevalence of general epidemics; as extensive tracts are frequently ravaged without such a phenomenon being observed. As it is clear, therefore, that earthquakes and volcanos cannot be the cause of the production of epidemic diseases, we must conclude, if there be any relation or connection between these different phenomena, that they are common effects of a common cause, and that cause volcanic action. As such, it only remains to ascertain in what way these various effects are produced. In so doing, we unfortunately enter a wide field of conjecture and doubt, as no theory has yet been proposed, which appears, to the generality of geologists, to account for all the phenomena known to depend on volcanic action. It is impossible, therefore, to refer to any acknowledged theory, in order to account for the mode in which these several effects are produced; as might be the case, if we had clear and distinct notions of what volcanic action really is. Under these circumstances, all we can do is to state the different theories entertained on this subject, in order to ascertain if they will, either separately or collectively, account for the production of epidemic diseases.

Various theories have been proposed by different individuals, at different times, in order to elucidate the nature of volcanic action. In the opinion of many writers, all the phenomena known as volcanic are to be referred, the same as epidemic diseases, to the action of electricity. This is more particularly the case with Noah Webster, who remarks: "My own opinion, respecting the material system, is this; that an atmosphere, the basis of which is electricity, fills infinite space, and involves, in its bosom, all the solid orbs, which shine in the celestial region. This may be denominated the *mundane* atmosphere, in opposition to that of the *ether* of Newton." (*Loc. cit.*, vol.

2, p. 507.) To this mundane, or electric, atmosphere, Webster ascribes the influence which the moon exerts on the flux and reflux of the ocean : as, also, on the eruptions of volcanos and earthquakes. He adds : "The theory, which ascribes earthquakes to steam or vapour, appears to be very unsatisfactory." . . . "There appears to be no way to account for the phenomenon, but by the great principle of action, *electricity !* Indeed, the discovery of the fact, that most earthquakes happen under particular phases of the *moon*, and that volcanic eruptions are obviously affected by her position in her orbit, seems to place this point beyond question." (Vol. 2, pp. 491 and 497.) "If we admit, then, the action of electricity to be the cause of earthquakes, we shall have reached the general proximate cause of those epidemic diseases, which speedily succeed concussions of the earth." (Vol. 2, p. 153.) Such conclusions hardly admit of a serious refutation. "Electrical phenomena," as Dr. Daubeny remarks, "are indeed common during the continuance of volcanic eruptions ; produced, in all probability, by the evolution of large quantities of steam and other elastic fluids, the decomposition and subsequent regeneration of water, and other processes, that accompany these grand operations of nature."* The same arguments, in fact, that have been employed against the hypothesis, when applied to the production of epidemic diseases, will also apply to its reception, when broached in order to account for volcanic effects. We must seek, therefore, for another and a better theory. That which is termed the "Nebular hypothesis," is the one generally adopted by geologists ; more especially as it is applied to the whole planetary system. Laplace, the originator of it, inferred, that the sun was originally a mass of incandescent matter, surrounded by a zone of

* *On active and extinct volcanos*, p. 524.

vapour—somewhat like the rings of Saturn. This vapour being thrown off from the revolving mass by the centrifugal action, and expanded beyond the force of attraction, would, it was assumed, be separated, coalesce, and form distinct globes, revolving round the sun. Hence the origin of the planets, and hence the reason, why the earth is considered to be a globe of fire, in the act of cooling down. According to this hypothesis, the formation of the volcano is to be ascribed to secular refrigeration, or the slow diffusion of the primitive heat; for as, under such circumstances, the crust of the earth must contract, as it cools down, the pressure thus exerted, on the internal and fluid mass, would necessarily cause a portion of the melted matter to be ejected, from time to time, on the surface—hence eruptions and earthquakes. Another class of geologists, concluding with M. Houell, in his *Voyage Picturesque,* that fire cannot exist alone, and without any pabulum, have referred volcanic action to a species of combustion; and various substances, which were supposed to be adequate to the purpose, have been named—as sulphur, petroleum, and other inflammable matter. The third, and last, theory to be considered depends for its formation on the brilliant discoveries of Sir H. Davy, as to the chemical composition of the alkalies, earths, and metals—substances of which the crust of the globe is chiefly, if not entirely composed. This distinguished philosopher has shown, that the base of these substances is highly inflammable; and its attraction for oxygen so strong, that it will abstract it even from water; giving rise, at the same time, to a sufficient extrication of light and heat to constitute a genuine case of combustion.*

* According to Dr. Daubeny, "The theories, which have been propounded, with the view of accounting for the existence of volcanic action, may be divided into two classes; those which

We will now consider the first of these theories—that which assumes the existence of a mass of incandescent matter in the centre of the earth. Independently of the reasons already given, this theory rests also for its support on the actual form of the earth—the spheroidal form—being that which a fluid body would assume if revolving in space. As, also, the mean density of the earth is much greater than distilled water—in the proportion of 5·44 to 1·1—and as there are proofs of the presence of melted matter beneath the surface, an additional reason appeared to be afforded why this fluid should have been igneous rather than aqueous. But Sir J. F. Herschel has shown, that the oblate figure of the globe may only have arisen from its long-continued rotation; this being the point to which, under this condition, it must tend, and which it would ultimately attain, even as its surface is at present constituted.* Professor Playfair also contends, that if the surface of the earth has repeatedly changed from sea to land, the figure of this our planet would ultimately coincide with its actual one.† Lyell, again, states, that Laplace has shown, by reference to astronomical observations made in the time of Hipparchus, that, in the last two thousand years at least, there has been no sensible contraction of the crust of the globe by cooling; for had this been the case, even to an extremely small amount, the day would have been shortened, whereas its length has certainly not diminished during that period by $\frac{1}{300}$ of a second."‡

Another reason has been adduced in support of the

assume some chemical process, of which the heat is merely an effect, and those which, assuming the existence of the heat, deduce the other phenomena from its presence." *A Description of Active and Extinct Volcanos*, p. 594.

* *Treatise on Astronomy.* † *Illustrations of the Huttonian Theory*, p. 435. ‡ *Principles of Geology*, vol. 2, p. 202.

"nebular hypothesis." This is the fact, that there is a gradual and sensible increase of temperature of the crust of the globe from the surface downwards, at least to those depths to which we have hitherto penetrated. Such proof cannot be of much value, considering how insignificant these depths are. The coal measures only extend five or six thousand feet below the surface, and the Devonian Basin to about twice as much. If we combine these depths beneath the surface with the highest mountain summits, we shall obtain nearly 48,000 feet—a measure equal to about $\frac{1}{524}$ part of the earth's crust. "All that is situated at a greater depth, is as unknown to us as the interior of the other planets of our solar system."* As such, it would seem to be somewhat doubtful whether this internal heat is derived from within or from without. The latter is the opinion of Poisson. "This hypothesis, imagined," as Humboldt observes, "by one of the profoundest mathematicians of our time, has not been received by physicists and geologists." And yet there are certain facts that would seem to confirm the conclusion. According to the calculations of M. Cordier and Professor Bischof, we should, on the supposition of a gradually increasing heat from the surface to the centre, and taking the increase we have hitherto obtained—about 1° Fah. in every 51 feet—as our guide, arrive at the melting point of iron at a depth not exceeding 24 miles. This, therefore, ought to be the termination of the solid crust of the earth, for such a temperature would be sufficient to fuse all the rocks composing the superficial crust of this our earth. But Dr. Daubeny and other writers have concluded, as the result of certain experiments and observations—some of which will be explained hereafter—that the solid crust of the globe extends to a depth of 800 miles—a conclu-

* *Cosmos*, p. 150.

sion that is fatal to the hypothesis of a central reservoir of melted matter. Then, again, if the increased temperature of the crust of the earth depended on internal heat, we should expect to find the same phenomenon with the waters of the ocean; but this is not the fact. It results from the observations of Kotzebue, Beechey, and Sir J. C. Ross, as a general fact, ascertained by thermometric soundings, that the deep sea water, *below a certain level*, determined by the latitude, is of *invariable* temperature throughout the globe, and *that a very low one*—the calculations of Linz, founded on Kotzebue's results, giving 36° F., and those of Ross 39.5° (which latter is the temperature at which pure water attains its maximum of density). The depth at which the fixed temperature is attained is about 7,200 feet at the equator, diminishing on either side of that line to Lat. 56°, where it attains the surface, and the sea (superficial currents apart) is of equal temperature *at all depths*. Thence, again, the upper surface of this uniform substratum descends, and at 90° of latitude has already attained a depth of 4,500 feet.* Sir Wyville Thompson stated, at the meeting of the British Association, September 12th, 1876, that the following was the result of the experiments made on board the Challenger during her scientific voyage. Over the whole *bottom* of the Pacific and the Atlantic, and those portions of the Southern Sea which they had examined, the temperature was usually a little over the freezing point. Down in the valleys, it sunk to pretty near the freezing point; in a few places a little below it. On the elevations, the temperature was somewhat higher. In the Atlantic, they found that, from about 500 fathoms to the bottom, the temperature steadily decreased till it came down to the freezing point, whatever might be the temperature of the atmosphere

* *Meteorology.* By Sir J. C. Herschell, p. 40.

above, or whatever might be the latitude.* It thus appears, that the temperature of the sea at the equator, at a depth of 7,200 feet, is not more than from 36° to 39° F.—a decrease instead of an increase as we descend—the contrary to what is observed on land. But there would seem to be no reason why the same law should not hold good in the one case as in the other, if the temperature of the lower strata of the crust of the earth depended on a central fire. Some difference might arise from the greater readiness with which the heat would be diffused in the ocean, as, also, by the mixing of the equatorial and the polar currents; but this effect would be trifling at the equator. As such, the temperature of the ocean in this region, at 7,200 feet, instead of being 36° F., ought to be, taking that of the earth as our guide, 141° F. This is without reckoning the influence of the upper stratum of air, heated to 70° or 80° F. Then, again, although the effect of the polar currents would be greater in temperate latitudes, or in Lat. 50°, still, a gradual increase of temperature ought to be experienced on descending to the lower depths of the ocean, but none has been found. It is only in the arctic regions that there is any increase of temperature below the surface; while this increase is very trifling, being only six or seven degrees above the freezing point—the invariable temperature of the ocean when uninfluenced by external causes.† Instead of the actual temperature, the ocean, if this hypothesis were true, would be a sea of boiling water, as it would repose, at a depth of four miles, on strata having a

* The *Times*, Sept. 14, 1876.

† Peron concludes, from his own observations, as well as from those of Irvine and Forster, that the deepest abysses of the sea, like the summits of our mountains, are covered with perpetual ice, even under the equator. *Journ. de Phys. t.* 59, *p.* 361, *and Ann. du Mus. d'Hist. Nat. t.* 5. p. 123.

temperature of 400° F. The contrary being the fact, we may infer, that the temperature of the ocean—local and accidental circumstances apart, as the presence of the Gulf stream—is dependent on the temperature of the air above. No proof, therefore, can be obtained of the existence of a central reservoir of melted matter from this phenomenon—the gradually increasing temperature of the crust of the globe—any more than from the preceding hypotheses; and no other arguments, worthy of consideration, have been adduced in support of the conclusion.

On the other hand, there are many facts, which would appear to negative the idea of a central reservoir of fluid, incandescent matter. One is, that the density of the earth is greater at the centre than at the surface. The most recent experiments with the balance of tortion are those of Reich, and give, for their result, 5.44 to 1, as the ratio of the mean density of the earth to that of distilled water. But the density of the rocks and strata, that form the superficial crust of the globe, is, it has been calculated, not more than 2.7, or, if we take that of the land and the sea combined, 1.6. It follows, therefore, that, either from pressure, or from the heterogeneous nature of the substances, which compose the interior of the globe, there is a great increase of density from the surface to the centre. In order to show, that this density does not arise from the presence of solid strata; and in order to support the "nebular hypothesis," it has been computed, at what depths liquid, and even gaseous substances might, from mere pressure, attain a density equal to that of platinum or of iridium; and, in order, as Humboldt has remarked, to bring the actual degree of ellipticity of the earth into harmony with the hypothesis of the infinite compressibility of matter, Leslie conceived the interior of the earth to be a hollow sphere, filled with "an imponderable fluid of enormous expansive force." If, however, such were the case, and if the interior of the globe be a mass of incandescent matter, lava would never cease to flow, after a vent had been once formed, until the external and the internal pressure were alike. As, also, we have proof, that vents have existed, on the surface, for thousands of years, the density of the centre of the earth ought, on this hypothesis, to be much less than that of the surface at the present time. The contrary being the fact, we may conclude, that the interior of the earth is not a hollow sphere, but is fillèd with solid matter. This is Lyell's opinion, who observes: "Experiments made with the pendulum, and observations on the manner in which the earth attracts the moon, have shown that our planet is not an empty sphere, but, on the contrary, that its interior, whether solid or fluid, has a higher specific gravity than the exterior." (*Loc. cit.*) Whether this matter was originally in an incandescent state, or not, is immaterial at the present moment; all we have to do now is, to ascertain whether the lava, thrown out from time to time on the surface, comes from a central reservoir. That it does not, may be shown by a number of facts. It may be remarked, in the first place, that it would seem to be hardly probable, if possible, for melted matter to be ejected from a central reservoir through the solid crust of the earth—800 miles in thickness—without destroying—at least, in the first instance, and before a vent had been formed—whole continents. So far from this being the case, the eruptions of volcanos are usually attended with less violent and general effects than when earthquakes occur, and when lava is not thrown out. Another circumstance is no less conclusive. It is generally allowed, that the expulsion of lava from the interior to the exterior is due to the expansive force of steam—produced by the precipitation of water on the melted matter contained in volcanic foci. This conclusion appears to be confirmed by the well known fact, that all volcanos are found near to the sea, or great inland collections of water. It is also to be borne in mind, that the fissure, or volcanic vent, is generally formed in secondary strata, composed of rocks, which, by their solidity and texture, may be supposed to offer a great and effectual resistance to the escape of pent up aqueous or other elastic matter. Hence we may conclude, that the formation of a volcanic vent is due to the accidental and sudden contact of water on an intensely heated surface, and the consequent generation of a large quantity of steam, which, unable to find an outlet, rends asunder, by its expansive power, the superincumbent strata; ejecting, at the same time, not only the pent up gaseous matter, but a portion, also, of the melted lava. If, however, there be a gradual increase of temperature from the surface to the interior, as must be the case if the "nebular hypothesis" be true; and if the crust of the globe be 800 miles in thickness; how is the water, we might ask, to penetrate to the central reservoir? If iron would be fused at a depth of only 24 miles, water would, as Gay-Lussac has remarked, be converted into steam, long before reaching the strata which are at a white heat. As such, it could not, according to this theory, be the moving power. The strata, also, in the craters of elevation of volcanos, do not, as pointed out by Daubeny, indicate, by the angle they form, that the lava comes from a great depth. Again, if the matter, which issues from volcanos in different parts of the world, came from a central reservoir, or common *focus*, we should expect, that the vents, in this case, would be scattered irregularly over the surface; at the same time that they held, while in a state of activity, a general and common relation to each other. Such, however, is not the case; for volcanos are invariably grouped together in particular regions of the earth's surface, occurring, as Von Buch has already remarked, either scattered along particular lines of the earth's surface, or, else, united in clusters around some common centre—hence the division into linear and central volcanos. It may also be stated, as a fact, that the volcanos in one region, line, or cluster, hold no relation with those in another and distant part of the earth—while it is as clearly ascertained, that the vents in one particular line or cluster communicate freely with each other. It would therefore appear, that the lava thrown out from volcanic vents, instead of being confined to one common and central focus, is derived from *various and separate reservoirs*—a supposition in accordance with all the facts presented to our notice on these occasions.

There is another circumstance which requires consideration. Although it might be possible, supposing the "nebular hypothesis" to be true, to account for the ejection of melted matter from the interior to the exterior, at certain points of the earth's surface, it will never explain, why the phenomena, attendant on the eruption of the volcano, should vary so much at different times, or, according to the date of its formation. Thus, when a volcanic vent has been formed, the matter ejected at first is almost entirely aëriform, consisting of smoke, aqueous vapour, and gases of different kinds: this is followed at a longer or shorter interval—in some cases not for centuries—by the discharge of melted matter which, together with the products just named, or a part only, continues to be thrown out, at irregular intervals, for a period that varies under different circumstances. After a time, solid matter is no longer ejected, but gaseous substances alone; until, at a still longer period, these products, also, cease to be given out. These different circumstances have occasioned volcanos to be divided into active and extinct, modern and ancient; according as they are in a state of activity or inactivity, and according, also, as their formation happened during or before historical periods. For instance, in the first eruption of Vesuvius, A.D. 79—no record of such an event having occurred previously—smoke, or gaseous matter, aqueous vapour and ashes, were alone given out. It was during this eruption, that Pompeii and Herculaneum were buried under the ashes or, rather, mud then ejected. Between this date and 1036, there were five more eruptions, but no lava was thrown out until the seventh. Since then, lava has been ejected at each eruption, and the volcano may be said to be in a state of full activity; the eruptions being frequent and severe. When, however, we turn to the most ancient of the active volcanos, those of the Andes, before described, we find, that there is scarcely an eruption once in a century; and that, when it does occur, ashes, water, and mud, are alone discharged. We may therefore assume, that the time is not far distant—geologically speaking—when these volcanos will become extinct. In other regions, again, where extinct volcanos are alone found, the only evidence we have of the previous existence of volcanic action, is the presence of thermal springs: while even this proof is wanting in other localities. In this case, the existence of volcanic rocks, and the crater-like form of some hill, will be the only indications, that volcanic action occurred in that particular spot, at some remote period,—ages, perhaps, before the formation of man. Now if each vent, on the surface, communicated with one central reservoir, containing incandescent matter, there can be no reason why the products should vary so much in different regions, consisting of aëriform matter in one, and melted lava in another. Besides, this gradual increase and diminution in the state of activity of a volcano, and this variation in the products at different periods, as well as the total inactivity of the volcano after a certain interval, would seem to show, that volcanic action is local not general; and that it exists only for definite not indefinite periods. The action, in fact, is similar to that of combustion on the surface; or, to the melting of iron in a furnace, excepting as regards its duration.

These circumstances would seem to favour the next of the theories referred to; for they lead to the conclusion, that the action which gives rise to volcanic effects is simply one of combustion. Hence Werner, the author of the Neptunian theory, considered that volcanic action was due to the combustion of beds of inflammable matter. But, then, we are unable to understand, how the common process of combustion can take place, or be kept up, in closed reservoirs without the presence of oxygen. We are, it is true, totally unacquainted with the mechanism of the globe; or the means of communication which may exist, between the interior and the exterior, so as to afford the necessary supply of oxygen, in order to keep up the combustion; while it has been inferred, that combustion might occur without the presence of oxygen. Lemery showed, that a mixture of sulphur and iron, sunk in the ground, and moistened, produced combustion: sulphurous vapours being extricated, and even flames. And Breislac concluded, that petroleum was the substance: the combustion being produced by certain combinations of phosphorus or of sulphur. But as the products of combustion, to quote the expression of Mr. Brande, always have reference to the combustible, the substances, given out from the vents of volcanos, cannot be referred to the combustion of either sulphur, petroleum, or other combustible matter existing on the surface. Besides, the accidental combustion of these substances, at short distances beneath the surface, and within the observation of man, gives rise, as the opponents of this doctrine have remarked, to a train of effects altogether different from those of volcanos; as we have proof of in the accidental burning of coal mines in many parts of Great Britain; in the combustion of masses of petroleum, as at Baku; and of sulphur or bituminous matter at Macabila.

We are thus forced by the apparent failure of the other hypotheses, and by a sort of *reductio ad absurdum,* to regard the last of these theories, in order to see, if that will account for the production of all the phenomena, known to depend on volcanic action. Although we are unacquainted with the metallic bases, on the surface of the globe, in their pure or primitive state, it has been argued by those who adopt this theory, that there must have been a time, when these substances existed uncombined with any oxygen. It is therefore fair to infer, that the process of oxygenation may still be incomplete in certain situations, and at those vast depths to which air and water have not yet been admitted. If this be granted, all that seems necessary, in order to produce combustion, or inflammation, in these beds, or veins, of pure metals, is the sudden or accidental contact of atmospheric air or water. Now those acquainted with the daily and constant changes going on, not only on the surface, but, also, in the crust and interior of the globe, will not be surprised, if both atmospheric air and water should penetrate, from time to time, to situations and depths, where neither the one nor the other had found access before. There seems, therefore, no *à priori* absurdity in imagining, as one writer has remarked,* that volcanic action may consist in a process

* *Encyclopædia Metropolitana,* Art. Geology.

of oxygenation, caused, in part at least, by the presence of the metallic bases, and their combustion, or union, with oxygen: while, also, we may add, it will explain nearly all the facts connected with the origin and continuance of volcanic action, at the same time that it accounts for those anomalies which belong to the other theories. Nevertheless, many objections have been made to this chemical theory, so many, in fact, that it is entertained by few in the present day—the majority of geologists having adopted the "nebular hypothesis," to the rejection of all others. As one writer has remarked: "It is certainly true that, if this theory (the nebular hypothesis) be not adopted, there is no central idea in the science, nothing about which it can crystallize; and that the whole assemblage of facts, so laboriously collected in physical geology, is without anything to compact it into one harmonious whole." * Still, we ought not to retain a false theory, merely because we are unable to account for the phenomena by any other. Nor ought we to reject a theory, merely because it is in opposition to our preconceived opinions, or because, as Dr. Daubeny quaintly observes, it smells of the laboratory. "The majority, indeed, it is conceived, of those who make the subject of volcanos their study," adds the above writer, "have allowed themselves to be biassed by the authority of certain great names amongst mathematicians—of men, who, chiefly anxious to connect the leading facts with those grand conclusions to which their own speculations have conducted them, regarding the internal heat of the planets, concern themselves but little with any minor details, as bearing upon a science in which they take but little interest."† (*Loc. cit.*, p. 594.)

One of the objections raised to the conjecture of Davy,

* *North American Review*, April, 1869.

† *A Description of Active and Extinct Volcanos*, etc , 1848, p. 594.

is the difference between the specific gravity of the earth and of the metals, in their pure state. The mean density of the earth, as already mentioned, is 5.44 : but the specific gravity of potassium is only 0.86 ; of sodium, 0.97 ; and of the metals of the earth, 1.2. This difference is considered to be fatal to the theory ; but this can only be so, on the supposition, that the whole interior of the earth is composed of pure metals. If, however, we infer, that the metals occupy only a portion of the earth's crust, the previous objection falls to the ground. It will be of little importance, what the specific gravity of the combustible matter may be, if it be only contained in separate beds of limited extent—in veins, as it were, the state in which we generally find them. The above objection, therefore, is not a valid one.

Another objection, raised by Professor Bischof, is the supposition, that "no possible amount of chemical action could engender so much heat as is here assumed." * But the amount of heat would necessarily depend on the quantity of combustible matter present, and on the quantity of other matter, that became melted by the substance in ignition ; as, also, the time during which the process was in operation. If the combustible materials existed in large quantities, and if the chemical action were kept up for a long period, as might be the case in closed reservoirs, the proportion of melted matter would necessarily be the same ; in which case it might retain its intense heat for centuries. "If," as Lyell remarks, "lava currents of moderate thickness require many years to cool down, in the open air, we must conclude, that the great reservoirs of melted matter, at vast depths in the nether regions, preserve their high temperature and fluidity for thousands of years." These conclusions appear to be confirmed by

* *The Edin. New. Phil. Journ.*, vol. 20, p. 373.

certain facts, observed on the surface, and cognisable to the senses. Not only do we meet with beds of inflammable matter near the surface; but, when they become ignited, they continue burning for long periods. The old Bassett Pit, at Parkgate, near Sheffield, has been on fire for a century, and is still burning. Springs and lakes of petroleum, as, for instance, that at Trinidad, have preserved their heat and fluidity from time immemorial. This objection therefore, like the former, is insufficient to invalidate the chemical theory. Lastly, Bischof remarks, if the lava were formed by the union of the metallic bases with the oxygen of the water, the quantity of *pure* hydrogen, emitted by volcanos, would be immense—a result that is not observed. But Gay-Lussac, assuming that water supplied the oxygen in volcanos, endeavoured to account for the absence of uncombined hydrogen, among the emanations from volcanos, by supposing it to form such combinations with other bodies as would not inflame, when coming into contact with the air. This is the case, when it combines with chlorine to form muriatic acid gas—a substance that escapes in large quantities from the ducts of volcanos, as well as sulphuretted hydrogen.* This explanation does not satisfy Bischof, who considers, that there is not chlorine enough evolved to unite with so enormous a quantity of hydrogen: an objection that would not, perhaps, have been raised, had it not been assumed, that the gaseous products evolved from the ducts of volcanos are the same as those produced at the commencement of the process. This is an error. It is apparent, that the action which produces the melted matter, must have existed for a long period—centuries perhaps—before the formation of the volcano, and previously to any eruption. To assume, therefore, that no free hydrogen

* *Annales de Chemie et de Physique.* T. 37, p. 133.

is evolved at the commencement of the process, merely because it is not found in abundance at a later period, is alike unphilosophical and absurd. No valid objections, therefore, would appear to have been offered against this chemical theory. It matters not, however, as regards the present inquiry, whether these objections be valid or invalid, or whether what is known by the term volcanic action, be the process conjectured by Davy or any other. It is sufficient, for the present argument, to conclude, that it is a particular process, which exists for definite, not indefinite periods; and that the melted matter is contained in superficial and separate reservoirs, not in a single or central one. This conclusion is strengthened and confirmed by the researches, made since the first edition of this work was published, of a profound mathematician.*

Mr. Hopkins, assuming that nothing is, as yet, known on the subject, enunciated the following propositions. (1) The earth may consist of a solid exterior shell, and an internal mass, in a state of fusion. (2) It may consist of an exterior shell, and a central solid nucleus, with matter in a state of fusion between them. (3) The earth may be solid from the surface to the centre. In order to solve these problems, Mr. Hopkins considered, that "a test

* Some of these observations and experiments, or, rather, mathematical calculations, were published previously to the publication of my work, in 1841, but they were not completed until the following year: while I was unacquainted with them until long after. A few years previously to this, or the publication of my work, a paper was inserted by me, in the *Boletin de Medicina, Cirujia y Farmacia*, No. 64, August 20th, 1835, during my stay in Madrid, in which the proposition was laid down, that epidemic diseases are produced by volcanic action, and for the following reasons:—1st. Que tanto la accion volcánica come las enfermedades epidémicas estan ambas sujetas à leyes, ó idénticas, ó muy parecidas. 2nd. Que estos duos efectos de una misma causa, aunque opuestos ó por le menos distintos, son siempre mas ó menos los compañeros el uno del otro."

might possibly be found in the delicate, but well-defined, phenomena of precession and nutation.* "As the precession of the equinoctial points, arising from the nutation, or oscillation of the earth's axis, is due to the attraction of the sun and moon, and principally the moon, on the protuberant matter at the earth's equator, it follows, if these parts were solid to a great depth, the motion thus produced would differ considerably from that which would exist, if they were perfectly fluid, and incrusted all over with a thin shell only, a few miles thick." It is not necessary to enter into any detail of the elaborate calculations and experiments made by Mr. Hopkins: those interested in the subject can refer to the original papers, entitled *Researches in Physical Geology*, and inserted in successive numbers of the *Philosophical Transactions*, from 1839 to 1842. It will be sufficient, on the present occasion, to give the result at which the writer has arrived.

Mr. Hopkins remarks: "Upon the whole, therefore, we may venture to assert, that the minimum thickness of the crust of the globe, which can be deemed consistent with the observed amount of precession, cannot be less than one-fourth or one-fifth of the earth's radius—or from 1,000 to 800 miles." If, however, the crust of the earth, as thus shown, be of this thickness, the propulsion of melted matter from a central reservoir, would be, as previously remarked, scarcely possible in the present condition of this our globe. This is Mr. Hopkins' opinion, who remarks: "Many speculations, respecting active volcanos, have rested on the hypothesis of a direct com-

* In astronomy, the precession of the equinoxes is a slow, but continual shifting of the equinoctial points from east to west. The amount of precession, annually, is about 50 seconds. Hence, the equinoctial points will make an entire revolution in 25 years. Nutation is a vibratory motion of the earth's axis, arising from periodical fluctuations in the obliquity of the ecliptic.

munication, by means of the volcanic vent, between the surface and the fluid nucleus beneath; assuming the fluidity to commence at a depth little, if at all, greater than that at which the temperature may be fairly presumed to be such as would suffice, under merely the atmospheric pressure, to fuse the matter of the earth's crust. When it is proved, however, that the crust must be several hundred miles in thickness, the hypothesis of this direct communication is placed, as I conceive, much too far beyond the bounds of all rational probability to be for an instant admitted, as the basis of theoretical speculation. We are necessarily led, therefore, to the conclusion, that the fluid matter of actual volcanos exists in subterranean reservoirs of limited extent, forming subterranean *lakes,* and not a subterranean ocean." And it is then added: "Such, also, we conclude, from the present thickness of the earth's crust, must have been the case for enormous periods of time; and, consequently, that there is a very high degree of probability, that the same was true at the epochs of all the great elevations which we recognise, with the exception, perhaps, of the earliest. If, moreover, we find, that the hypothesis of these subterranean lakes, at no great distance beneath the surface, does enable us to account distinctly, by calculations founded on mechanical principles, for the phenomena of elevation, and the laws which they follow, then have we all the proof of the truth of our hypothesis, which the nature of the case will admit.* † Sir Charles Lyell has

* *Phil. Trans.* 1842, p. 42.

† M. Delaunay, the eminent astronomer, has brought forward some objections to the arguments advanced by Mr. Hopkins; but Sir W. Thomson, after a careful consideration of them, states, that the hypothesis of a viscous fluid, assumed by M. Delaunay, can be mathematically proved to be insufficient for the phenomena, which cannot, he believes, be accounted for, unless the crust of

arrived at a somewhat similar conclusion, not from mathematical calculations, but from simple deduction. He remarks: "That lakes of lava are continuous for hundreds of miles beneath the Chilian Andes, seems established by observations made in the year 1835. According to Mr. Caldcleugh and Mr. Darwin, the whole volcanic chain of the Chilian Andes, a range 1,300 miles in length, was in a state of unusual activity, both during the shocks, and for some time preceding and after the convulsion, and lava was seen to flow from the crater of Osorno. In November of the same year, Conception was shaken by a severe earthquake, and, on the same day, Osorno, at the distance of 400 miles, renewed its activity."

This conclusion—that of a *lake* of melted matter—although highly important, is insufficient, in my opinion, to explain all the effects resulting from volcanic action: the majority of these effects being observed along extended and well-connected lines of the earth's surface, as must be evident from what has gone before. I should therefore conclude, that the melted matter forms, not lakes but subterranean rivers, extending over large portions of the terrestrial sphere—a distance, in many cases, as great as from the pole to the equator, or from one pole to the other.

If there be a subterranean river, there must also be a subterranean cavity, or tunnel, beneath the surface, extending the same distance. That such is the case, we may conclude, not only from what has gone before, but, also, from the phenomena witnessed during the occurrence of earthquakes. It is generally supposed, that the earth-

the earth have a thickness of, at least, 2,000 or 2,500 miles, and a rigidity approaching that of a globe of solid glass.—*Comptes Rendus*, July 13, 1868, and *Nature*, Jan. 18, 1872, p. 233, and Feb. 1, p. 257.

quake, like the eruption of the volcano, is produced, as previously stated, by the expansive force of steam, due to the accidental contact of water on the melted matter. Other geologists conclude, that it is caused by the condensation and sudden expansion of elastic vapours in pent-up reservoirs. Be this as it may, it is considered, by the majority of geologists, that the shock of the earthquake is derived from a common focus, and thence propagated through the strata in particular directions. Mr. Mallett, who has paid particular attention to the phenomena of earthquakes, and who has attempted to reduce the study of them to something like a science—the science of Seismology—infers, that the shock, or earth-wave, is a true undulation of the solid crust of the earth: or, as he expresses it, in another place, "the transit through the earth's crust of a wave of elastic compression." * † Were this the case, the effects resulting from earthquakes ought to be felt, principally, in a circular direction, and vertically rather than horizontally. But Humboldt states, that the circular, or gyratory, earthquake is the most rare: the vertical less so, and the horizontal, or linear, the most common. "The shocks," adds the Baron, "are propagated chiefly in a linear direction, by undulations having a velocity of from 20 to 28 geographical miles a minute."‡ Mr. Mallett also states, that "the motion of translation of the earth-wave, or shock, is rectilinear, not curvilinear." Why this should be, it seems difficult to understand, on the hypothesis of the shock being propagated from a

* These conclusions of Mr. Mallett are of course based on the "nebular hypothesis"—on the supposition, that the melted matter is propelled from a central reservoir to the surface, through a duct; and that the point of departure of the concussions is from this duct, or subterranean chimney.

† On the facts of earthquake phenomena. *Report of the British Association*, 1850. Vol. II., p. 273.

‡ *Cosmos*, p. 192.

central focus of limited extent, and from a vertical shaft: more particularly when we find that the lines, in each volcanic district, are invariably the same, at each concussion; and that, although extending over considerable portions of the globe, their lateral boundaries are very limited. Then, again, concussions occur, along the whole of this extended line, passing gradually from point to point, at particular intervals, and being limited, for the time, to these particular spots. At other times, instead of progressing regularly along the line, a concussion will be felt at one point only; at another time, at another point, the shocks being confined to an area of limited extent. How then are we to account for these phenomena, by the ordinary hypothesis? Are there vertical shafts beneath the surface, and scattered along the whole of these lines? That is not probable, more especially when no volcano exists, as is sometimes the case, along the whole line; or, when, if there be any, they are only to be found at one or two points of a line, extending from Asia to the continent of America. These are anomalies that cannot be explained, on the supposition of the shocks being propagated through the solid strata from a central area of limited extent, and by the escape of steam through a vertical shaft. Were this the case, we should expect to find, that earthquakes were more violent in the immediate neighbourhood of the volcano than elsewhere: but this is not the fact. On the contrary, the concussion is usually the severest at a distance from the volcano, and in situations where no volcanic vent exists.

Independently of the shocks, noises are sometimes heard during an eruption or an earthquake, at a spot where no shock is felt, and at long distances from the volcano, or the place where the concussion occurs: and this, too, when no sound is heard in the intermediate places.

In 1744, at the eruption of Cotopaxi, subterranean noises, as of cannon, were heard at Honda, near the Magdalena river. Not only is the crater of Cotopaxi about 18,000 feet higher than Honda, but these two points are separated from each other by a distance of 436 miles, and by the colossal mountain masses of Quito, Pasto, and Papayan, as well as by countless valleys and ravines. "The sound," remarks Humboldt, "was clearly not propagated through the air, but through the earth, and at a great depth."* (*Loc. cit.*, p. 195.) The great depth is a supposition of the renowned traveller, not confirmed by experience.† He also remarks that, in the Caraccas, in the grassy plains of Calabaso, and on the banks of the Rio Apure, which falls into the Orinoco, there was heard, over the space of 2,300 square (German) miles, a loud noise resembling thunder, unaccompanied by any shaking of the ground: whilst, at a distance of 632 miles to the north-east, the crater of the volcano of St. Vincent, one of the small West India Islands, was pouring forth a prodigious stream of lava.‡ § How, then, is this phenomenon to be explained? Mr. Mallett, the great authority on this subject, remarks:— "The occurrence of sound at all, necessarily infers *impulse* at the focus, of the nature of a blow, or a succession of them; either due to fracture of hard and elastic material; the sudden separation, or rending open

* *Cosmos*, p. 195.

† Mr. Mallett calculates that, in the Calabrian earthquake of 1857, the greatest number of the wave-paths started from a *vertical depth* not exceeding 3 geographical miles or 18,225 feet. The maximum depth he gives at $8\frac{1}{8}$ geographical miles, and the minimum depth at $2\frac{3}{4}$ miles.

‡ It may be as well to remark, that the volcanic line of the West Indies is prolonged westward across the continent of America, and intersects the Chilian line.

§ *Personal Narrative*. Vol. IV., p. 27.

further, of existing fissures, or cavities; or, the sudden rush out of highly elastic steam, or its as sudden production, or condensation." (*Loc. cit.*, vol. 2, p. 286.) If the noise, in these instances, be the effect of an impulse on the solid crust of the earth, at such distances, the intermediate places ought also to exhibit the same phenomenon: but this is not always or generally the case. Then, again, the noise is not always synchronous with the concussion. It was not until some time after the great earthquake of New Grenada, November 18, 1837, and described by Boussingault, that subterranean detonations, *unaccompanied by any movement*, or shock, were heard, with great regularity, at intervals of 30 seconds, throughout the whole Canca valley. Humboldt also states, that the great subterranean detonation (*il gran ruido*), which was heard at the cities of Quito and Ibarra, but *not* at Tacunga and Hambato, which were nearer the centre of the movement, occurred 18 or 20 minutes after the catastrophe, or the concussion. It also appears, that the noise, which accompanies earthquakes, bears no proportion to the violence of the oscillations. "I have distinctly ascertained," observes Humboldt, "that the great shock of the earthquake of Reobamba (4th of February, 1797) —one of the most terrible phenomena in the physical history of our globe—was unaccompanied by any noise." (*Loc. cit.*, p. 194.)

As the noise and the shock are not invariable accompaniments the one of the other, or synchronous; and as the noise is frequently heard at great distances from the spot where the concussion is felt; while the intermediate places are unaffected; we may reasonably infer, that the detonations are not produced by an impulse on the solid crust of the earth, at a distance from the spot where they occur. At other times, again, noises are heard without any shock being experienced, either at that spot or elsewhere. The most striking instance of uninterrupted subterranean noise, remarks Humboldt, unaccompanied by any trace of earthquake, or concussion, is the phenomenon which is known in the Mexican territory by the name of *Bramidos y truenos subterraneos* (or, subterranean roaring and thundering) of Guanaxuato,—a rich and celebrated mountain city, situated at a distance from any active volcano. For instance, on the 9th January, 1784, the noise began at midnight, and lasted above a month. From the 13th to the 16th, it was as if there were *heavy storm-clouds under the feet of the inhabitants,* in which slow rolling thunder alternated with short thunder-claps. Neither at the surface, nor in mines, 1,598 feet deep, could the slightest trembling of the ground be perceived. (*Loc. cit.,* p. 196.) As, also, these noises are only heard in particular spots, and on certain lines of the earth's surface, it would seem to be impossible to account for their production, except on the supposition, that there are subterranean cavities extending along these lines, for the whole of the distance. Such an inference will enable us to explain, not only some of the anomalies already considered, but, also, why earthquakes are sometimes progressive, commencing at one particular spot, and then extending, slowly and regularly, at certain intervals, along well-defined lines, and over considerable spaces of the terrestrial globe.

The rate at which the shock, or the sound, is propagated, also leads to the conclusion, that there is a hollow cavity beneath the surface, in the direction in which these effects are perceived. According to Humboldt, earthquakes travel at the rate of from 20 to 28 miles in a minute: but it is less than this in many instances. Mr. Mallett calculates the velocity of the earth-wave, or shock, at

12,039 feet per second—equivalent to about 13 miles in a minute. Now this is very nearly the rate at which sound is propagated through the air—$12\frac{1}{2}$ miles per minute. This circumstance would lead to the conclusion, that both the shock and the sound are propagated, not through the solid strata, but through air, or a medium having about the same density. If so, there must be a subterranean cavity, or tunnel, filled with air or some elastic fluid, through which the sound passes—it being evident that the sound travels beneath, not above the surface. If it were propagated through the solid rocks, as inferred by Mr. Mallett, it would travel more rapidly—3 times more rapidly through lias, 6 times through limestone, and 10 or 12 times more rapidly through hard slate and burnt clay.

With these facts before us, the only inference to draw would appear to be, that the melted lava beneath the surface forms rivers not lakes, and that the reservoirs, in which it is contained, are tunnels of narrow dimensions but of great lengths. This inference receives support from the nature of the sound. In the narrative of the New Zealand earthquake, in 1855, it is remarked: "The noise is like the noise of a railway train, running *through a tunnel*, when a person is standing at the mouth." The character of the concussion also leads to the same conclusion. The motion then produced on the surface of the earth—a wave-like one—has been compared, by Mitchell, to a carpet, under which air is blown. In the earthquake in Jamaica, in 1692, an eye-witness stated, that the ground heaved and swelled "like a rolling, swelling, sea," insomuch that people could hardly stand upon their legs by reason of it. So, also, in the concussion in New England, in 1755, the tops of the trees were observed to vibrate *ten* feet, like the pendulum of a clock. Effects like these could hardly be produced by a shock, or impulse, at a given point, and thence transmitted through the solid strata, without causing a disruption of the earth's crust along the path of the earthquake. If, however, we conclude, that there is a hollow beneath, at no great depth, the difficulty ceases. It is only on this supposition, that we can understand the slight damage that sometimes occurs during severe concussions. This circumstance has not escaped the observation of Mitchell, who remarks: "What must the size of that cavern be, which could contain vapour enough to produce the earthquake of 1759; or how can we suppose, that the roof of such a cavern, when so violently shaken, should avoid falling in." It has been computed, that the earthquake at Lisbon pervaded an area of 700,000 geographical miles: or the 12th part of the circumference of the globe. If, however, instead of a central reservoir or circumscribed cavity—the lake of Mr. Hopkins—in each volcanic region, we infer, that a narrow and lengthened tunnel exists, extending over considerable spaces of the terrestrial sphere, the elastic vapour generated at such times might rush along this tunnel, without rending asunder the solid crust of the globe; as would inevitably be the case if confined within narrower boundaries. Such a result, it is true, does frequently occur, but the effects are insignificant compared to those that would otherwise be observed.

Having thus attempted to define what is termed volcanic action, and endeavoured to show the manner in which volcanic effects are produced, we may now proceed to consider the way in which epidemic diseases arise—it having been assumed, that they, also, are products of the same cause. As before stated, it is generally allowed, that the eruption of the volcano, and the shock of the earthquake, are produced by the precipitation of water on the melted matter contained in volcanic *foci*. If, however, the ejection of lava, from the interior to the surface, be due entirely to the accidental presence of steam; we must allow that, at other times or in other situations, where the same action is going on, this phenomenon cannot be witnessed, from the absence of those contingent circumstances necessary for its production. These are, the contact of water with the melted matter; its conversion into steam in sufficient quantity to overcome the weight of the superincumbent strata; and its confinement within certain boundaries, so as to be able to exert a hydrostatic pressure sufficient to produce a volcanic vent, and the propulsion of the pent-up matter. Such being the case, we cannot be surprised to find, that volcanic eruptions take place so seldom, even in situations where earthquakes are frequent and common; for the power, that is insufficient to rend asunder the crust of the globe, may, nevertheless, be adequate to produce, not only slight tremors but even violent concussions. We must also infer, that even this effect, at other times and in other situations, cannot take place; although the process itself, whatever that may be, which is known by the term volcanic action, is in existence at the time. Thus, if water does not percolate at all to the reservoirs of melted matter or only in small quantities, no concussion can be felt, if we allow, that earthquakes are produced by the same cause as that which gives rise to the eruption of the volcano—a conclusion, that we are bound to admit in the present day; for we may, as Lyell truly remarks, regard earthquakes as abortive volcanic eruptions. Granting, however, that the shocks sometimes felt on the surface of the earth are produced, not by the expansive power of steam, but, as some geologists would have us believe, by the condensation of other and permanently elastic gases, the product of the volcanic process;

still, it is evident, even then, that this phenomenon can only be produced under particular circumstances; for unless gaseous matter be evolved in sufficient quantity, and unless it be confined for a sufficient length of time, to produce the necessary condensation, no concussion would be felt.

But, then, it would be most unphilosophical to suppose, because we have none of those great catastrophes, which proclaim the operation of this cause on the crust of the globe, that the action productive of them is dormant, either during the interval of their occurrence, or in situations where these phenomena are not observed at all. On the contrary, we have proof, that this action does not cease with the subsidence of the above effects; as a variety of circumstances show, that volcanic foci retain their intense heat for ages. We may therefore assume, with a writer in the *Encyclopædia Metropolitana*, "that the eruptions of burning mountains are only the external manifestations of a cause generally diffused throughout nature; and that the minor indications of the same may therefore be looked for, when these mightier ones are unknown." This is confirmed by numerous phenomena; for, as Lyell states, "perennial supplies of hot vapour and aëriform fluids rise to certain craters, which are in a state of ceaseless eruption. Numerous solfataras, evolving the same gases as volcanos, serve as permanent vents of heat generated in subterranean regions. The plentiful evolution, also, of carbonic acid from springs and fissures, throughout hundreds of square leagues, is another regular source of communication between the interior and the surface. Steam, also, often above the boiling temperature is emitted for ages, without intermission, from 'stufas,' as the Italians call them. Even silex, carbonate of lime, muriate of soda, and many earths, alkalies, and metals, are poured out in a state of solution by springs, and the solid matter, which is thus tranquilly removed in this manner, may, perhaps, exceed that, which issues in the shape of lava." In fact, it is probable, as the above author suggests, that we owe the comparative tranquillity of our globe to the efficacy of this ceaseless discharge of heat, and of solid, as well as of gaseous matter. But it is principally in the neighbourhood of extinct volcanos, or in situations, where earthquakes have been frequent, and chasms formed, that these phenomena are observed. We have proof, however, of the evolution of gaseous matter from subterranean reservoirs at other times, and in other situations. This effect is most apparent during the eruption of the volcano, particularly on its first formation; as must be familiar to all who have perused the accounts of such visitations. A remarkable example was afforded by the eruption in the island of St. Vincent, in 1812, which began by an abrupt and dreadful crash from the mountain, called Souffriere; and was proclaimed, in a moment, by a vast column of thick, black, ropy smoke, like that of an immense glass-house. On the following day, it appeared like a compact, pitchy, column, rising perpendicularly from the crater to an immense height. Those who have witnessed an eruption of Vesuvius, must also have remarked the column of vapour rising from the crater during the day, and the glare at night, caused by the ignition of some of the gases then evolved—the flame being invisible in the daytime. Minor effects of the same kind are also observed during the occurrence of earthquakes. But, in addition to the gaseous matter discharged from the craters of volcanos, and the fissures formed by earthquakes, at the time of the eruption of the one and the occurrence of the other, various gases are also given out from the bowels of the earth, *silently and* *invisibly*, before the above phenomena are observed; although, for obvious reasons, the source, whence the matter is derived, is not so evident in this instance as in the former—its diffusion in the atmosphere being so gradual as to be nearly imperceptible. The phenomenon, however, has been observed to precede eruptions and earthquakes so frequently, and to occur in situations and at times when no other reason can be assigned for its production, that no doubt can possibly exist as to the cause. Thus, for some months previously to the eruption of Hecla, Iceland, in 1783, the atmosphere of the whole island was filled with a dark, bluish, sulphurous vapour, or cloud, which was stationary in calm weather, and, at other times, was blown over the neighbouring countries. So, also, in the memorable earthquake at Lisbon, in 1700, a thick fog was perceived on the morning of the fatal day, both in that city and in other places near; while a remarkable haze, or mist, which obscured the sun's rays, was also visible on the *day preceding* the tremendous concussion, which laid Lisbon in ruins in 1755. Humboldt, referring to the phenomena that occurred during an earthquake at Cumana, says: "On the 18th October, a reddish vapour rose above the horizon, and covered, in a few minutes, as with a veil, the whole azure vault of heaven." From the 28th October to the 3rd November, the mist became denser and denser, and, on the 4th, there were two shocks of an earthquake. So, also, the remarkable fog, of the month of May, 1783, described by Fourcray, preceded the earthquake in Calabria *by a month.* In fact, everything in earthquakes, as Humboldt has observed, seems to indicate the action of elastic fluids, seeking an outlet to spread themselves in the atmosphere.

Remarking, therefore, that gaseous matter is thus given out from the bowels of the earth, not only at the time, but antecedent to the eruption and the shock, it is necessary to ascertain how this evolution takes place. If the reservoirs from which these gases are derived, exist at a comparatively slight depth beneath the surface, it is easy to conceive, that they may, under certain circumstances, escape through the superincumbent strata,—even when a pressure much less than that, which produces the shock and the eruption, is alone exerted. But it will, in other cases, be impossible to draw such an inference, as the solidity and nature of the superincumbent strata must prevent their escape in this direction; for although earthquakes are most frequent on tertiary formations and in alluvial districts, they are not entirely confined to these situations, but are also witnessed on secondary, and, sometimes, on primary formations. As it is clear, that the evolution of gaseous matter from the bowels of the earth, before any fissure or vent has been formed on the surface, could not take place through the interstices of the majority of the rocks composing those formations termed primary and secondary, we must look to some other means for the production of this effect.

In so doing, we are at once led to regard those natural outlets, formed by the streams which penetrate to various depths; and convey to the surface that fluid, so necessary for the health and the life of man. Now these streams, or springs, abound in all situations, being found in the hardest rock as well as in the soft and humid beds of alluvial tracts. They are, however, more abundant in the latter situation than in the former—while they are comparatively rare in primary formations. If springs, therefore, penetrate to volcanic foci, to such channels we may, in all probability, look for the discharge of those gases, which escape from the interior to the exterior, before the formation of any vent or fissure. This inference is strengthened by the fact, that *thermal* springs exist in the neighbourhood of all active volcanos, at the same time that their production can generally be referred to the same epoch as the volcano itself; while, also, it has been found, that the same mineral and gaseous matters are contained in their waters, as those which are given out from volcanic vents. The relation, indeed, as Sir Charles Lyell justly observes, of almost all springs, impregnated copiously with mineral matter, to the sources of subterranean heat, seems placed beyond all reasonable doubt by modern research. More than this, we find that these springs continue to give out the same substances, and to retain their increased temperature, long after the volcano has become extinct; by which it would appear, that the products of volcanic action escape more readily by these channels than from the ducts of volcanos. As it is evident, that the waters of mineral springs penetrate to volcanic foci, the question of most importance at the present moment is, do the same products, and especially gaseous matter, escape by the same channels, or by ordinary springs, at other times, and in situations in which no sign of volcanic action is in existence? That such is the case, we may infer from numerous phenomena. Thus, previously to the concussion or the eruption, the sea frequently swells up and makes a great noise, at the same time that the waters of the neighbouring springs are observed to become muddy and to overflow—effects which are frequently experienced at considerable distances from the spot, where the concussion occurs. Whether the waves produced in the sea, at the spot where the concussion is felt, be the effect of an alteration in the level of the land, which forms the bottom, or whether it be the effect of some other cause, must be matter of opinion and discussion. But of this there can be no doubt, viz., that gaseous matter escapes in large quantity from the waters of the ocean, not only during eruptions and earthquakes, but, also, *before any shock has been experienced.* Thus, before the earthquake which happened at Oporto in 1755, the river opened, and seemed to discharge an immense quantity of *air*. Again: Previously to the earthquake which occurred in Calabria in 1638, the sea, as we are informed by Kircher, seemed to wear a very unusual appearance: those who have seen a lake in a violent shower of rain, all covered over with bubbles, may, says this writer, have some idea of its agitation. It is also recorded, that the fishermen, at the same time, were obliged to relinquish their occupations, and to land; for though *there was no wind*, yet the sea, for some distance, appeared to be in an extraordinary state of ferment and ebullition. It is remarkable, also, that seamen sometimes observe a swelling of the ocean *without wind*, and before any shock has been experienced; and this fact Pliny mentions among the signs of an approaching earthquake. This phenomenon can only, we may presume, be ascribed to the escape of gaseous matter from the bottom of the sea; and this matter, we may further infer, is derived from the mouths of those springs, which rise up as freely beneath the waters of the ocean, as on the surface of the dry land.

This inference receives support from the fact, that the same agitation in the water has been observed in situations far removed from the centre of the concussion; and when no shock has been perceived, either then or subsequently, in the solid crust of that part of the globe. This was very remarkable at the time of the earthquake at Oporto, just referred to. It was only in Portugal, that any elevation of the superincumbent strata took place: but agitation, or movement, in the waters of the sea, rivers, &c., was observed in France, England, Germany, and even as far as Norway and Sweden. That the waters of the ocean should have been affected in situations, far removed from the centre of the concussion, will not, perhaps, excite surprise, when it is known, that an immense wave was produced at Oporto, and that ships at sea a considerable distance from the coast also felt the concussion. But, independently of the sudden flow and ebb of the water on the sea-coast in England, Holland, Norway, &c., the same agitation was observed in *inland collections of water*, as ponds, lakes, &c. Thus, at the same time as the concussion in Portugal, and the agitation of the sea in that and other countries, the water in ponds in various parts of England, and in the canals and dikes in Holland, was observed to be agitated, and to have its level altered. At White-rock, Glamorganshire, the water suddenly rose in the river, floated two large vessels, the least of them above 200 tons, broke their moorings, and nearly upset them. This effect, says the writer of the account, *was not felt in any other part of the river;* so that it (the water) seemed to have gushed out at that very place. This sudden movement in the river, in ponds and canals, could, we may conclude, only arise from the discharge of water or gaseous matter from the springs, which rise up at the bottom of these inland collections of water. At least, this would seem to be the only fair inference, when we find, that no concussion was felt on the dry land for hundreds of leagues from the spot where the phenomenon occurred. This conclusion is strengthened by the fact, that at Toplitz in Bohemia, and many other places, the hot springs had their contents rendered turbid; at the same time that large quantities of water rushed out with great violence, on the day that the concussion occurred. We may further infer, that this sudden discharge of water from springs is produced by the escape of gaseous matter through these particular channels. That the movement in the water of ponds, springs, &c., in places far removed from the centre of the concussion, and in situations in which no other effect referrible to the same cause has been observed, is produced by the escape of gaseous matter from the springs beneath, may be inferred from a phenomenon, stated to have taken place at Amsterdam and other places. This was a sudden vibration and movement in the chandeliers, and other pendulous articles, in the churches and houses, at the moment when the agitation in the waters was observed, although the atmosphere appeared to be perfectly calm. This effect admits of explanation, by supposing that there was a sudden rush of air from some source; and as the water in the canals and dikes—and which, be it remembered, had no communication with the sea, and could not, therefore, be influenced by the immense wave produced in the ocean—were similarly affected, it is fair to infer, that the elastic matter, which gave rise to the phenomenon, was derived from the springs beneath—especially as the effect was too sudden and too great to have been produced by any insensible concussion of the crust of the globe. These inferences are strengthened by another fact, which is, that the same phenomena were actually observed, in some places, before the concussion. Mitchell states, that the agitation in the waters of Lochness, Lochlommond, &c., preceded the earthquake at Lisbon by about *half an hour*. The same result was observed in Switzerland, the agitations in the water of the lakes having, according to M. Bertrand, occurred three quarters of an hour before the earthquake.

Having thus shown, that there is a considerable evolution of gaseous matter from the interior to the exterior, previously to, during, and subsequently to, the eruption of the volcano, and the shock of the earthquake, it only remains to ascertain, whether any of the gases thus extricated be of a poisonous nature. That such is the case, admits of no doubt, as extensive disease and mortality frequently occur after volcanic eruptions and concussions, among the inhabitants of the surrounding districts. Although the population of Iceland did not then exceed 50,000, more than 9,000 human beings, and an immense number of cattle, perished during one eruption only of Hecla. This loss is to be referred, partly, to the depredations of the lava, and, partly, to famine; but, principally, to the noxious vapours which impregnated the air. So, also, the consequence of the earthquake in Jamaica, in 1690, was, we are told, a general sickness — 3,000 persons of those who survived the effects of the shock being swept away by pestilence. In the Calabrian earthquake, A.D. 1783, upwards of 40,000 persons, according to Sir William Hamilton, were killed; and 20,000, he calculated, died of disease subsequently. Again: In the eruptions in Italy in 1329, every species of animals, with multitudes of the feathered creation, perished in great numbers; and Seneca relates, that a vapour, caused by an earthquake in Campania, destroyed 6,000 sheep. But deleterious substances are not only given out from the vents of volcanos, and the fissures formed by earthquakes; they also escape from the mouth of those springs, that discharge their contents beneath and into the waters of the sea, as is shown by their effect on the finny race. Thus in the eruption, which took place in the island of Lancerote, in 1730, dead fish floated on the waters in indescribable numbers, or were thrown dying on the shore. In June, 1731, also, during a renewal of the eruptions, all the banks and shores, in the western part of the island, were covered with dying fish of different species; some of which had never been seen before.

The preceding are not the only channels, by which gaseous matters escape into the surrounding atmosphere from volcanic foci; they are also given out from the surface, or from particular soils on the surface. Humboldt states, that in the Savannahs of New Andalusia—a volcanic region—flakes of fire rise to a considerable height: they are seen for hours together in the dryest places; and it is asserted that, on examining the ground, which furnished the inflammable matter, no crevice is to be found. Hence the source of the deleterious emanations, that are found to exist in certain situations; not occasionally only but continuously. About mid-way between Vesuvius and Mount Vultur is the *Lago di Ansanto* (the ancient *Amsanctus*), celebrated for the mephitic gases which it exhales. The quantity of gaseous matter that escapes from one spot of a small rivulet, which flows from the lake, is so great, that Dr. Daubeny, in his visit to that part of Italy, was obliged to make a detour to avoid it. This is the origin of the fable of the *Vado Mortale,* according to which the rivulet cannot be forded without death; and where the whitened bones of the animals, that had perished there, remain without anyone being able to approach near to remove them. Formerly, there was a wood situated between this lake and the town of Villa Maina, four miles distant, but, since this was cut down, the inhabitants have suffered materially in their health, and particularly from affections of the liver. Dr. Daubeny also states, that, "in the island of Milo, as well as in the Phlegrœan fields near Naples, noxious miasmata so abound, that the few inhabitants of this once populous island are the very pictures of wretchedness and disease."*

* Near to Mount Vultur,—an extinct volcano, in the kingdom of Naples,—are the remains of a temple, that was dedicated to the goddess Mephitis; and Romanelli mentions an inscription, found on the road near, of a votive offering, presented to the goddess by a Roman lady—thus: *Paccia Quintilla Mifeti votum solvit.*

Observing that gaseous matter is given out thus freely from volcanic *foci*, and in situations where no vent or chasm exists, it is, probably, to this source that we must look for the origin of those extensive mists, or fogs, that so frequently occur, but the cause of which has hitherto been regarded as inexplicable. We shall be strengthened in this conclusion, when we find that these fogs have been observed more particularly at epidemic periods, and in well-known volcanic regions; although, as might be inferred, they also prevail in situations in which no evidence exists of volcanic action. Thus, the plague of Egypt, in Pharaoh's time, was attended by darkness; as was that in Rome, A.D. 252 and 746. In the plague which desolated Rome, B.C. 296, there was also a remarkable darkness, under favour of which the Samnites attacked the Roman lines. We also hear of the same phenomenon during the prevalence of the black death of the 14th century; for the majority of writers speak of the thick, stinking, fog, which accompanied the march of this plague:—"A dense and awful fog," says one writer, "was seen in the heavens, rising in the east, and descending upon Italy."* Hence, Hodges, in his treatise on the great plague in London, 1665, concluded, that it was produced by a subtle *aura*, or vapour, extricated from the bowels of the earth. Similar results have been seen and noted during the prevalence of murrains. Thus, thick mists (of a bluish colour) were observed to precede the diffusion of the memorable murrain described by Dr. Winklan; a malady which broke out in Italy,† and spread through Switzerland, Germany, Poland, and Holland, until at last it reached England. The fatal angina maligna among cattle, in 1632, was also attended with a blue mist, or dew, on the herbage or pastures.

The same phenomenon has been observed during the

* *Mansfield Chronicle.* † *Phil. Trans*, Vol. XIII., p. 93, A.D. 1683.

prevalence of the epidemic cholera, fogs and mists having been its accompaniment both in the East and in the West, while they have prevailed to so great an extent as to attract general attention. The first account we have of the phenomenon comes from China, and is contained in the work of M. Hue, a Jesuit missionary. He remarks :—

"In the first year of the reign of the deceased Emperor [it must be remembered that one has died since this was written]—that is to say, in the year 1820—a mass of reddish vapour was noticed one day upon the surface of the Yellow Sea. This singular phenomenon was observed by the Chinese of the province of Chang-tong, which forms its coast. The vapour was at first light, but gradually increased, became condensed, rose little by little above the surface of the water, and at last formed an immense red cloud, which remained for several hours floating in the air. The Chinese were seized with terror, as they mostly are in the presence of all great natural phenomena, and sought in certain superstitious practices of the Bonzes the means of averting the threatened calamity. . . . . . Whilst the inhabitants of Chang-tong were seeking to conjure away this unknown misfortune, which yet every one foresaw, a violent wind suddenly began to blow, and, dividing the cloud into various columns, drove them on toward the land. These red vapours spread in a winding course along the hills and valleys, and swept over the towns and villages; and, wherever they passed, men found themselves suddenly attacked by a frightful disease, which, in a moment, deranged the entire organisation, and changed a living man into a hideous corpse. In vain did the doctors anxiously turn over their books; nowhere could they find any hint of this new, strange, and terrible enemy, that struck like a thunderbolt, sometimes on one side, sometimes on the other—on poor and rich, young and old—

but always apparently in the most capricious manner, without following any fixed rule in the midst of its fearful ravages. Numberless remedies were tried, numberless experiments made, but entirely without success, and the implacable scourge went raging on with unabated fury, plunging whole populations into terror and mourning.

According to all that the Chinese have told us of this terrible malady, it was incontestably the cholera.* It ravaged first the province of Chan-tong, then turned northwards to Pekin, striking always in its march the most populous towns. At Pekin, its victims were proportionally more numerous than elsewhere. Thence the cholera crossed the Great Wall, and the Chinese say, that it faded away in the land of grass."† Fogs do not appear to have been noticed in India—only a peculiar and unusual cloud. An officer, who witnessed the different attacks of cholera in Brigadier Smith's force at Seroon and other places, informed Mr. Orton, that the epidemic was invariably accompanied by a large black cloud, hanging over the place. This, he added, had been so universally remarked, that it had received the name of "the cholera cloud."‡ Many observers have drawn attention to the same circumstance, now and at former epochs. Caius Britannicus states that, in addition to a noisome smell, which preceded the sweating sickness, a "black cloud" was seen to move from place to place, while the pestilential disorder was observed *to follow* exactly the route of the cloud.§ In Europe, these fogs have been more frequent, and have been better observed. On the first

* As there can be no doubt, that the disease was the epidemic cholera, we have proof, that it appeared in China, three years after it sprung up in Bengal. Its course eastward, therefore, was more rapid than to the west.

† *The Chinese Empire*, pp. 286-7. ‡ *On the Epidemic Cholera.*

§ Van Swietan, *Comment.*, Vol. XVI., p. 21.

appearance of cholera at Dantzic, on the 27th of May, 1830, there was a very unusual, dense mist,* and it became, accordingly, dark long before sunset. It was commonly reported, said Dr. Hamick, by many persons, who were abroad, that the mist had a peculiar, disagreeable smell and taste, so that those exposed to its influence were forced to wash their mouth with water. A similar mist appeared just before the first appearance of the disease in Rheimfeldt, and again in Dantzic on the 8th June following. I have heard, continues the above writer, this fact of the concurrence of mists with the first appearance of cholera stated by several; and Dr. Barchewitz obtained written statements of it by conscientious and intelligent observers, so important did he deem it. The same phenomenon preceded the first outbreak of cholera in England. On the 11th of August, 1831, a thick mist of a tawny-orange colour passed across England, in a direction from south-east to north-west, or from Dover to Liverpool. On the following day, many persons were attacked, in Rochester, with bowel complaints, attended with severe spasms. Fogs were also observed in 1832, and in the subsequent visitations—in 1849, 1854, and in 1866—but it was not until the last-named year, that public attention was specially drawn to the subject. Mr. Glaisher, in a letter to the *Times*, states:—"During the prevalence of the epidemic of cholera, in the year 1854, my attention was directed to the general and particular atmospheric conditions which prevailed during the visitation. Among them I noticed a certain blue mist, present night and day, which I connected with the epidemic conditions of the atmosphere, and mentioned in my report upon the meteor-

* Mist is not the proper term to apply to these exhalations, as the gaseous matter is generally dry, and uncombined with aqueous vapour – to any extent at least.

ology of London in relation to the cholera epidemic, addressed to the then President of the Board of Health, and which was published by him. Last Monday, July 30 (1866), on looking from the grounds of the Royal Observatory, Greenwich, under the trees, towards the boundary walls of the park, I saw the same dense, blue mist, which has continued without intermission to the present time, though somewhat less in density this morning. Ordinary mists pass away, when the wind blows with a pressure of ½lb. on the square foot. Since last Monday, we have had pressures of the wind varying from ¼lb. to 9lb. on the same area, blowing continuously for sixty to seventy hours, yet there has been no change in this blue appearance. I have examined the atmosphere daily for this blueness, particularly during the last twelve months, and have never seen anything like it since the year 1854. In my recent quarterly reports to the Registrar-General up to the last published—viz., June 30—I have stated, that no meteorological choleraic conditions had been present, and none certainly appeared up to July 22. During the following week, I was in the Isle of Wight, and on my return to the observatory, on the 30th of July, I at once saw the same phenomenon that I had remarked in September, 1854. I am therefore unable to say when it first appeared. This blue mist is apparent on all sides; it extends fully to the tops of the trees, though it is not then so easy to distinguish. It is most easily discernible through as much atmosphere as possible, viewed from under a tree, looking under other trees. Thus seen, the boundary walls of Greenwich Park, and all objects near them, are coloured blue; or through gaps in trees, if there are others at a sufficient distance to form a background, when it resembles thin smoke from a wood fire. The intensity of the blue is increased when viewed through a telescope with a low power. It is of great importance to know whether it is general over the country. The only other tint of mist I know, connected with the prevalence of epidemics, is that of a yellow mist, perceptible in like manner when scarlatina is prevalent; in neither case is there any excess of humidity in the air." Other observers noted the same phenomenon, and recorded the fact. It was generally supposed, at the time, that the phenomenon was a new one, or had not been observed before; and a correspondent, in one of the daily newspapers, who signed himself 'Y,' added: "Medical practitioners, who are, for the most part, feebly imbued with the spirit of true philosophy, will be disposed to ridicule this notion (of a connection between fog and cholera) from a feeling of mortification, that it should have escaped the attention of their own profession." Had the writer been acquainted with the first edition of this work, he would have known, that the phenomenon had been recorded many years before, and an attempt made to explain the cause of it. The same phenomenon was observed during the prevalence of the cattle plague in 1865. Mr. Garne, of Bushey Grove Farm, Watford, writing to Mr. Woods, respecting an outbreak of this disease, among some lambs, remarked: "Just previous to their being attacked, we had very heavy fogs during the evening, the pastures being covered with what is commonly called cobweb, and the air being, as it were, full of it. In a few days, the grass fields were covered with a peculiar kind of blight, which collected on the shoes similar to a fine powder of a pale chocolate colour; the clovers were covered with mildew. Soon after this, the lambs showed the symptoms I have described to you." This coincidence has been noted from the earliest periods. Thus, God said to his people, by the Prophet, Amos: "I have smitten you with blasting and mildew;" and we are then told, in the next verse, that a pestilence prevailed with men and horses.

That the gaseous matter diffused in the atmosphere, at these periods, is derived from volcanic *foci* may be inferred from the circumstance that fish have been attacked and died, at epidemic periods, the same as terrestrial animals —the very phenomenon that has been observed during volcanic eruptions. In A.D. 222, a pestilence, which destroyed 100,000 persons, raged in Scotland: at the same time, a great mortality of fish was noticed, and multitudes were washed ashore on the coasts of Great Britain. The old author, Cedrenus, relates that, during the dreadful pestilence, which brooded over almost the whole earth, in the latter part of the 6th century, a vast quantity of fish died in many places. According to Baronius, "a pestilence, which was truly most fatal to the human species, was no less so to aquatic animals; for the banks of rivers were covered with dead fish, which putrefied and infected the air with an intolerable stench." (Book 10.) "In 1240," says Webster, "mortal diseases prevailed, and authors relate, that the fish on the English coast had a battle, in which 11 whales, and a multitude of other fish, were slain and cast ashore. The cause, to which this phenomenon was ascribed, although ludicrous enough, is important; for it strengthens modern observation, that, when pestilential diseases prevail on the surface of the earth, fish often perish beneath the waters." So, also, when the black death was prevailing, there was, in addition to a murrain amongst the cattle, a pestilence, which carried off immense quantities of fish, whose bodies were found on the sea-shore covered with blotches.

The same phenomenon has been observed during the prevalence of the epidemic cholera—multitudes of dead fish having been found, at this time, in ponds in India, Russia, Prussia, and other countries. The subject of the epidemic constitution on animals, during the prevalence of cholera, was brought before the faculty of Vienna, by order of the Imperial Government. They remark, in their Report, after referring to the fact of all classes of animals being more or less affected, that, "although the peculiar agency is still problematical, yet it appears to be satisfactorily proved, not to depend exclusively on the condition of the atmosphere, since animals that live in water only—as fish, crabs, leeches, etc.—died in great numbers at the time of the cholera epidemic." At Havre, the citadel of which is surrounded by a deep ditch, that always contains a large quantity of fish, a remarkable circumstance, as we are told by Dr. Licardi, took place in the month of August, 1832, the year of the prevalence of the epidemic cholera in France. "It was remarked by many persons," says this writer, "that the water here suddenly changed its colour and became muddy; while *bubbles of gas* rose to the surface, and caused a considerable ebullition. At the same time the fish, and particularly the eels, which are almost constantly at the bottom, were observed to spring above the surface of the water with a convulsive movement, and then to drop again, languid and heavy, into that fluid which, after having been the source of their life and nourishment, was found to act upon them as a poison; for, in a few hours, the surface of the water was covered with dead fish. The inhabitants of the neighbouring sea were not exempt from the operation of the same cause, the sea-shore being likewise covered with an immense quantity of dead fish."* *A few days after* the cholera broke out in the town, and raged with considerable violence. The only piscatory epidemics, that have been recorded since then,

* "*Sur la coincidence des Epidemies humaines avec celles des poissons.*"

are the following. Referring to the scarcity of oysters, one writer remarked: "Graziers and milkmen will remember this eventful year by the *cattle plague*, and farmers by the tantalising weather of harvest; 'gourmands' and 'gourmets,' however, will speak of it as the year of the 'hegira' of natives, when oyster knives rusted for want of use, and the months with the 'r' in them came, but not the molluscs of the season. It is the same abroad as at home. The dredging on the French coast is a failure, and in Paris those baskets thatched in with straw, which come up from the north-west ports, are hardly to be seen. Epicures go about, repeating to each other a dismal prophecy, that a dozen truffles will be cheaper this winter than a dozen oysters. That the scarcity arose principally from disease, not from excessive consumption of this favourite 'bivalve,' may be inferred from the fact, that, in Norway, where the consumption of oysters is great, a strange illness, which resulted in the sudden death of several persons, was ascribed to the oysters, which were said to be suffering from a species of oyster plague." (The *Standard*, May 28, 1866.) Corroborative evidence is thus afforded of the extrication of deleterious substances from subterranean sources, during the prevalence of epidemic diseases; as we know of no other means by which results like those described could be produced.

That the dense fogs so frequently experienced at epidemic periods, are derived from the same reservoirs as those which supply the ducts of volcanos, we may infer from the fact, that some of these fogs appear to obey the same laws as all other and well known effects of volcanic action. Thus fogs are frequently confined to very narrow boundaries—not only intersecting a country but even a town; so that while one part has been enveloped in a dense fog, the remainder has been quite free. Although the boundaries of fogs are thus defined, they are, nevertheless, found to extend over considerable spaces in some particular direction; while, in other instances, different localities have been enveloped in fog at the same moment. Not only are fogs confined, in general, to very narrow boundaries, and to particular lines of the earth's surface, but they are sometimes found to progress along these lines, and to precede or accompany some particular pestilence. This was the case with the mist, that accompanied the murrain of the 17th century, described by Dr. Winklan, and which extended over the same countries as the disease, and had, like it, a regular rate of travelling,—being about 14 miles an hour.

It may be replied, however, that these fogs are observed in situations, in which no proof has been obtained of the existence of this action, as, also, at long distances from any active volcano. This objection vanishes, when we find, that the same phenomenon is observed at times, when no doubt can exist as to the source whence the gaseous matter is derived. Webster states, that on the 19th May, 1780, a day of singular darkness occurred in New England, and in the Middle States. The heavens were obscured with a vapour, or cloud, of a yellow colour or faint red. On the same day, that this lurid vapour overspread several hundred miles of country in America, Etna began to discharge lava from a new mouth, distant two or three miles from the old crater. It may also be argued, that these mists are only accidental, not invariable accompaniments of epidemic diseases; and, as such, cannot be the cause of their production. This argument is probably a just one; for the poisonous element may, if contained in the air, be sensible neither to the sight nor the smell, as is certainly the case with the poison termed malaria. In fact, the mists and fogs, which accompany the march of epidemics, are merely proofs, that a great evolution of gaseous matter takes place at such periods from the interior of the globe; while all that we are warranted in concluding, is, that a poisonous element of some kind may be extricated at the same time, and from the same sources. It is, also, to be remembered, that these mists are principally observed in cold and damp climates; in warm regions, phenomena of a different kind are experienced. With the exception before mentioned, and the existence of a peculiar "cloud" in the atmosphere, the only evidence of the presence of vapour in the atmosphere in the East and in Asia, has been a redness of the sun's disk, and a peculiar kind of haze in the upper regions, with obscurity of the sun's rays.

Independently of the above, there are other proofs of the presence of a deleterious or foreign matter in the atmosphere at all epidemic periods. In the destructive plague which raged in the year 262, and when 5,000 persons died daily in Rome, Eusebius states, that the air was so highly corrupt as to form on objects a mould, or coat, like the turbid dew from dead bodies. Webster also remarks, that the air of New York, in 1779, produced astonishing effects in the generation of mould; and the rapidity in the process of putrefaction was almost incredible—a result very common in malarious districts. Impressions of curious figures on garments have also been observed during pestilential periods, while they have also been visible on the doors of houses, and other articles. This was particularly the case during the plague of 542 and 600. Similar figures, called *cruciculæ*, or little crosses, appeared in the pestilence of 746, and the writers of that period state, that they were looked upon with superstitious horror. The same impressions, or figures, have been observed after volcanic eruptions—as was the case after that of Vesuvius, in 1660, and referred to by Boyle.

If, therefore, epidemic diseases be produced by the presence of a deleterious matter in the atmosphere, as was before inferred; if extraneous substances, extricated from the bowels of the earth, be commonly present in the atmosphere at epidemic periods; and if there be proof, that gaseous matter, inimical to animal life, is given out from volcanic *foci;* while all the great pestilences with which we are acquainted, up to the present time, or before the advent of the epidemic cholera, have prevailed in well-known volcanic regions, we can hardly fail to infer, that they are directly produced by the operation of a poison generated in subterranean reservoirs; more especially as these diseases obey the same laws as other well-known effects of volcanic action. As regards the epidemic cholera, we have no direct proof at present, that it has progressed along a line known to be, or considered to be, volcanic, with the exception of a small portion of this line. Evidence, however, will be adduced hereafter, which tends to show, that volcanic action is actually in existence over a considerable part of this line—and precisely over that part not considered to be volcanic—concussions and other signs of this action having been observed since the advent of the epidemic cholera. But such evidence is not actually required, in order to prove the truth of the proposition now laid down. If, indeed, epidemic diseases be produced by the extrication of deleterious substances from subterranean reservoirs, the product of a process similar to that of combustion on the surface, the first effect of that process, we may presume, would be the evolution of gaseous matter into the atmosphere above; and, the next, disease in the animal creation. As, also, the evolution of this matter is a silent, and, usually, an invisible operation, we should expect to find, that the prevalence of some general disease would be one of the first signs of this process beneath the surface. This, at least, is the conclusion that I should draw on the subject.

These inferences receive support from the opposite series of facts. When free vents have been formed between the exterior and the interior of the globe, or the subterranean reservoirs beneath the surface; either by the formation of a volcano, or by its increased activity, so as to allow of the ready escape of the gaseous matter beneath, the diseases previously witnessed begin to decline. A remarkable example of this is afforded by the volcanic region of the Mediterranean. As is well known, the volcanos in this part of the world are found in three distinct districts, named the Sicilian, the Neapolitan, and the Grecian; but our knowledge is more perfect respecting the two former than the latter. In the first we have Ætna. This volcano appears to have been in a state of activity from the earliest periods of which we have any record; for an eruption caused the Sicani to desert the country, before the Trojan war. Thucydides also states that, between the colonization of Sicily by the Greeks, and the commencement of the Peloponnesian war, in the year 431 B.C., three eruptions had occurred: while there were nine others before the commencement of the Christian era. But from this date until 1329, only five occurred. In the Neapolitan district, all the volcanos were in a state of *inactivity* from the remotest periods, and until about three centuries before the Christian era. Terrific convulsions then took place in Ischia, and the neighbouring island of Procida, which were followed by eruptions in the former island; for a colony established by Hiero, King of Syracuse, was driven away by the concussions and igneous exhalations. But there was no eruption of Vesuvius until A.D. 79, when Pompeii and Herculaneum were buried under a shower of ashes or, rather, mud—*lava not being ejected.* In fact, we have no account of the flowing of a stream of lava from this volcano until the year 1036, being the seventh eruption from the above date. There was an eruption in 1049, and another, in 1138, or 9; after which a pause ensued of 164 years, when, in 1302, a lava stream flowed out from a new vent in the Island of Ischia. The next eruption occurred in 1306, between which and 1631 there was only one other (in 1500), and that a slight one. But during this period, or interval of repose, Ætna was in a state of unusual activity: no less than seventy-two eruptions having been recorded from 1329 until the end of the 17th century.*

There had thus been no violent eruption of Vesuvius for 492 years, when, in December 1631, seven streams of lava poured out at once from the crater, and overflowed several villages on the flanks, and at the foot of the mountain. In 1666, there was another eruption, from which time to the present there has been a constant succession of eruptions, with rarely an interval of rest exceeding ten years.† It has been precisely during this

* Ætna would appear to have thrown out lava in some of the earliest recorded eruptions, for the Carthaginian army was arrested by a stream of melted matter, during its march against Syracuse. It is probable, however, as was the case subsequently with Vesuvius, and as is generally the fact with all *recent* volcanos, that smoke, gaseous matter, and *scoriæ*, were principally given out at that period. In the eruption of 1669, when a new crater was formed, a stream of lava flowed out, and destroyed Mastaluccia, San Pietro, Campo Rotondo, and fourteen smaller villages, or hamlets: and was only arrested by the walls—sixty feet high—of Catania. From that time to the present, lava has been constantly thrown out at each eruption.

† During this increased activity of Vesuvius, Ætna has been more tranquil; seventeen eruptions only having been recorded from the end of the 17th century until the year 1819, while there were thirty-three of Vesuvius.

last period, that the plague has ceased to prevail epidemically in Europe; while its boundaries, or the extent of its range, have become more and more circumscribed—being now confined to a very narrow circle. The disease, in fact, disappeared, as it were, by zones, the last visitation in England, in the north of France, and in Switzerland, having been in 1666; and, in the south of France, in 1720. Independently of the reasons already given for this gradual subsidence of disease—the great and increasing facility for the escape of gaseous matter from the reservoirs beneath—another reason may be given for this result. If volcanic action be a chemical process, as has been inferred, giving rise to different products at different times, it is probable, that gaseous matter is not generated, or, at least, to the same extent, at that period when melted matter is thrown out on the surface in large quantities. Hence the subsidence of diseases under these circumstances.*

* In the Report of the Cholera, drawn up by order of the Registrar-General, the writer, Dr. Farr, thus concludes his notice of my work:—1st, The successive outbreaks of cholera in the districts of England have not, in 1832 or 1849, been preceded, accompanied, or followed, by any earthquake, or visible volcanic phenomena; 2dly, Cholera is, apparently, not more fatal in the immediate neighbourhood of volcanos than it is elsewhere; and, 3dly, The gases, which escape from volcanos, have been analyzed; but the poisonous element has not been identified, or detected, in places suffering from cholera." Nearly the same arguments have been employed, and similar conclusions drawn, by other writers. As will be evident from what has gone before, these facts, so far from being in opposition to my theory, are actually in accordance with it. These writers have confounded volcanic *effects* with volcanic *action*—to which alone I attribute the origin of epidemic diseases. In fact, volcanos, earthquakes, and epidemics, according to my ideas, are merely common effects of a common cause: and although intimately connected together, have no necessary dependence the one on the other.

This result will be still more apparent and remarkable, if we turn to those districts in which extinct volcanos exist or which have become nearly extinct. Thus, in the region of the Andes, the oldest range of volcanos, next to extinct volcanos, epidemics would appear to be unknown, while endemics are extremely rare.* Dr. Bryson states that, with some few exceptions, in which ague and malarious fevers exist, both sides of this volcanic chain are extremely salubrious.† Again: epidemic diseases are generally unknown in those places possessing mineral springs, which are invariably found in the neighbourhood of extinct volcanos; or in situations, in which evidence exists of the action of subterranean fire, at some remote period. Endemics, also, are very rare in such situations. Hence, nearly all these places escaped the ravages of the epidemic cholera, although many of them were lying in the direct route of the disease, and although surrounded by it in many instances. This was the case at Baku, and most of the mineral springs in Germany. At Swallbach, the epidemic, although prevailing severely in the suburbs, never reached the central part of the town. It appeared, as one of the resident practitioners said to me, as though the town were surrounded by a high wall, beyond which the disease was unable to penetrate. The same result was observed in Spain. A Spanish friend informed me, that, in 1854, while the cholera raged fearfully in Mataro and in Vilasar, not a single case occurred in Argentona, possessing mineral springs, and situated about a mile and a half from the former places. And yet, Argentona was

* According to Humboldt, these volcanos scarcely have an eruption once in a century; and, even then, they only throw out mud and water. The period, therefore, when they will become extinct is, probably, not far distant, geologically speaking.

† *Statistical Report of the Health of the Navy* from 1837 to 1843.

crowded with fugitives from both places at the time. With these facts before us, it would seem to be unnecessary to employ other arguments or to adduce further proof, in support of the proposition now laid down, viz. that epidemic diseases are the direct effect of the operation of a cause to which the term volcanic action has been applied. Dr. Hecker, although a contagionist, also infers, that epidemic diseases are produced by, or owe their origin to, what he terms telluric influence. By this term, he does not mean volcanic action, but an undefined, active principle—the vitality, or organism, of our globe. He remarks: "This disease (the black death) was a consequence of violent commotions in the earth's organism; if any disease of cosmical origin can be so considered." This notion, of an organic life in the system of the universe, which is an ancient one, and derived from the East, seems to be a favourite doctrine with Dr. Hecker, and other German writers. But, as Dr. Babington has justly observed, with reference to this opinion, we are constantly furnished with proofs, that that which affects life is not life itself. To assume, therefore, causes, of whose existence we have no proof, in order to account for effects which, after all, they do not explain, is making no real advance in knowledge; and can scarcely be considered otherwise than an indirect method of confessing our ignorance.* If, however, instead of supposing that the earth is endowed with an organism, or vitality, of its own, we infer, that the phenomena, which we have now been considering, are the effects of volcanic action; and that this action does not pervade the whole globe, but is confined to particular lines or districts; we refer to an agent, with whose existence we are acquainted, while we are also able, at the

* *Preface to the Translation of Dr. Hecker's work.*

same time, to account for nearly all the phenomena witnessed on these occasions.

If the preceding arguments and inferences be allowed, we shall not only be able to understand the cause—the real, the efficient, cause—of epidemic diseases, but we shall also be enabled to explain many of the anomalies that belong to other theories, and more especially to that of contagion. As volcanic action takes place along particular lines of the earth's surface, we can at once understand the cause of the progression, or the importation, as it is termed, of epidemic diseases from one country to another, without reference to human intercourse, or commercial traffic. As, also, the boundaries of these lines are of limited extent, an explanation is afforded of the apparent anomaly, that one part of a town is sometimes attacked to the exclusion of the other, and even one side of a street, the opposite not presenting a single case. In a town in Russia, consisting of only one street, all the first cases of cholera happened to be on one side of the street. Observing this, the authorities had a barrier put up to prevent communication between the infected and uninfected sides. The attacks were confined to the former, and the fact was brought forward as demonstrative proof of the contagious nature of the disease, and of the benefit to be derived from isolation. But the same phenomenon and the same result were observed subsequently in Ireland, although no barrier was erected, and although the communication between the two sides of the street was uninterrupted. A similar result has been observed in numerous instances. Mr. Chandler stated, that at Rotherhithe, the cholera in 1848, not only attacked one side of a street, leaving the other unscathed, but he also remarked, that the disease passed directly *across* certain streets in *a definite line*, like a cannon shot. The same anomaly has been remarked with the diseases of the brute creation. Francis Clater, in his work on Farriery, speaking of one of the murrains of the last century, adds: "A hedge often separated the dead from the living." "I recollect," also remarks Mr. Youatt, "that, in one of our barracks, the majority of the horses on *one side* of the yard were attacked by epidemic catarrh (1833), while there was not a sick horse on the other side."* So, also, in the Report of the Cattle Plague of 1865, Messrs. Simmonds and Brown state: "Sometimes, the disease has been seen to extend from farm to farm, always on *one side of the road,* the opposite roadsteads remaining entirely free from the disease" (p. 306). And yet, with such facts before their eyes, these writers are out-and-out contagionists.

Not only will the poison productive of these diseases be given out along particular lines of the earth's surface, but the gaseous matter will sometimes be extricated in greater abundance in one situation than in another, according to the nature of the soil or the means of communication that may exist between the interior and the exterior of the globe. Hence one town may be attacked and another spared, although lying apparently in the direct route of the disease. Thus it was that, in the plague of the sixteenth century, the towns of Verona and Padua were nearly depopulated, while the town of Vicenza, which lies between the two, was spared. The year following, however, this town was, in its turn, the theatre of the epidemic, whilst the other two remained unaffected. Schruber also states, that the most perfect health was often preserved near towns severely scourged; while places, the farthest removed, experienced all the horrors of the plague. Similar results have been frequently observed, during the march of the epidemic

* The *Veterinarian*, p. 117, 1833.

cholera from India to the shores of America. The same phenomenon is observed during the occurrence of earthquakes, certain spots being shaken, while the intermediate districts are spared—a common result in volcanic regions. Humboldt states, that the natives of South America call these unshaken spots—"bridges"!

Another circumstance well worthy of consideration, and which is entirely fatal to the doctrine of contagion, is the fact, that epidemic diseases frequently break out in different localities, widely separated from each other, almost simultaneously. Referring to the outbreak of cholera in India, in 1872, Dr. Cunningham, in his report, remarks: "The fact, that the epidemic, over so large an area, attained its greatest violence at or about the same time in many places, separated from each other by hundreds of miles, is of great interest in an epidemiological point of view." The same result has been remarked, not only in other countries, but on different continents, as Europe and America. The cause of the phenomenon will be at once apparent, by a reference to the theory now advanced; other effects of volcanic action, as the earthquake for instance, being frequently felt, at almost the same moment, along the same line, at separate and distinct points.

We can also understand, on the same hypothesis, why isolation is sometimes beneficial, and sometimes useless. As the poison productive of epidemic diseases would not, we may presume, be equally diffused in the atmosphere, but, like malaria, be more concentrated near the spot where it is extricated; while it would become innocuous, at certain distances, by dilution in the surrounding atmosphere; those placed in quarantine, or isolation, would necessarily escape an attack, if the deleterious matter were not given out, or only in small quantity, within the circumscribed area. On the other hand, if the gaseous matter were extricated in greater abundance at a particular spot, those confined there would suffer more than others. Hence, particular establishments, houses, or persons, are sometimes attacked, while others escape; the same whether there be, or whether there be not quarantine, or isolation.

Again: if diseases be produced by the presence of a gaseous substance in the atmosphere; and if the specific gravity of the gas be greater than that of atmospheric air—as is the case with malaria—an explanation is at once afforded of the well-known fact, that the night air is so injurious at epidemic periods, the same as in malarious districts. During the heat of the day, and the consequent rarefaction of the atmospheric air, the gaseous substance would be elevated into the higher regions; while it would as naturally fall again to the earth, by its own specific gravity, as soon as the rays of the sun were withdrawn. Medical officers in the navy are well aware that, sleeping on deck, or exposure to the night air in an open boat or on shore, in warm and pestiferous climates, is a prolific source of disease. Dr. Clarke states, that "a Danish ship anchored at Long Island, near the Straits of Sunda, and sent twelve of her people on shore to obtain water, where they only remained two nights. Every one of them was seized with fever, of which none recovered, but the rest of the ship's crew remained exempt."* "In 1782, the Assistance, man of war," says Trotter, "wooded and watered at St. Thomas (in the West Indies), and, with a view to expedition, a tent was erected on shore, in which the people employed on these services lodged during the night. On the middle passage, every man, who had slept on shore, was attacked with (yellow) fever and died, while the rest of the ship's

* *On the Diseases which Prevail in Long Voyages.*

company remained perfectly healthy."* A striking example of the injurious effect of exposure to the night air has been afforded by Humboldt, in the following narrative. Two rich inhabitants of the city of Mexico—where yellow fever is unknown—arrived in the evening at Vera Cruz—in which city the disease is endemic—in order to take the packet, which was to sail the next day for Europe. Being fearful of catching the fever, if they went into a house, they resolved to remain in their carriage all night—*al fresco*—but this did not save them: they were both attacked, in the morning, with black vomit, and died before the evening. Had they gone into the hotel, like the other passengers, none of whom were attacked, they would no doubt have escaped; more particularly if they had shut their bed-room windows. Such an act, however, in the torrid zone, would not be in accordance with the prevalent ideas in England: but it is not in a healthy climate like this, that men can study, with profit and advantage, the causes productive of disease. As the soldier can only acquire a perfect knowledge of his profession on the field of battle: so, also, a medical man must study diseases, there where they exist in their greatest intensity and to the greatest extent—viz., in pestiferous and intertropical climates—if he wishes to become perfectly acquainted with their origin and ætiology.

It is necessary to offer a few words of explanation, respecting an anomaly before referred to. It has been stated, under Law III., that epidemics are rare in mountainous regions: and that, as a general rule, they assume a milder form. There are, however, exceptions to this rule, as they sometimes prevail there more generally, in which case the disease presents a more severe form than on the plains below. The enigma is not difficult of solu-

* *Medicina Nautica*, Vol. I., p. 456.

tion. Generally speaking, the poisonous element is only extricated from alluvial soils, and tertiary formations; in which case, the poison will have become diluted, by its diffusion in the surrounding air, before reaching the higher elevations. Hence the mildness of the attacks, and their rarity. When, however, the gaseous matter escapes from the surface in elevated or mountainous regions, it can only be through particular channels, or springs, as the solidity of the rocks would necessarily prevent its escape through the superincumbent strata. As these springs are more rare than in alluvial districts—where, also, the gaseous matter evidently escapes from the soil itself, and must, therefore, be more equally diffused in the surrounding atmosphere—the poison, when extricated, would necessarily be more concentrated; and hence the severer form of the disease.

Another anomaly may also be referred to. It has been shown, in the previous part of this work, that sporadic, or single, cases of so-called Asiatic cholera exist nearly every year in England; and the same result is witnessed in other countries, and in other diseases, as small-pox for instance. Notwithstanding, the disease only spreads, or becomes epidemic, in particular years. It will also be found, on inquiry, that isolated cases have generally occurred some weeks or months before the actual, or general, outbreak of pestilence. The celebrated Mr. Boyle states, that, in 1665, *three months* before the plague broke out in London, a man sent for a physician, complaining of a swelling in the groin, from which circumstance he predicted the plague that followed. Again: it was assumed, and declared in *official* reports, that the cholera was imported into this country in 1866. But a genuine case of Asiatic cholera was admitted into Guy's Hospital more than a year previously, in May 1865; while thirty-two deaths from cholera were registered in London, in the course of the same year. There were even deaths, in England, from the same disease the year previously—1864. It is a pity that men, instead of searching for facts, thus draw on their imagination, and feign hypotheses, while quietly seated in their arm-chair! How, then, are these anomalies to be explained? They do not admit of explanation by a reference to the doctrine of contagion, as no reason can be assigned why a disease, presenting the same type and intensity, at all times, should not be propagated as readily at one time as at another, if it be contagious. If, however, these diseases be produced by volcanic agency, we have only to infer, that a large quantity of deleterious matter is extricated at one time, and over an extended space, and a small quantity at another, at some isolated spot, and the anomaly ceases.

Another phenomenon, inexplicable by the doctrine of contagion, admits of explanation by a reference to that under consideration. This is the fact, that troops on march, in India, have frequently been attacked with cholera, on encamping for the night on an uninhabited spot, in the interior of this vast continent: and this, too, when the disease was neither prevailing in the surrounding districts, nor had been for a long time previously. On one occasion, two corps encamped for the night on separate ground, but *near* to each other. In the morning, one corps was attacked with cholera, but the other remained entirely exempt. Observing this, the sick corps broke up its encampment, and took up a position alongside the healthy one; after which, not a case occurred, although the sick and the dying were removed at the same time. This was not a solitary instance, many similar ones having been recorded since. The following is another example of the same kind. Referring to the cholera epidemics in India, in 1864-5, one writer remarks: "The troops in Nagpore have suffered on both occasions, and the *high road*, between the terminus of the railroad and Nagpore, has been literally *a valley of death* for months together. Officers, their families, and native travellers innumerable, have fallen victims in attempting to pass it."* As the gaseous matter from volcanic *foci* evidently escapes with greater facility in one situation than in another, we may infer, that it found a more ready exit in these localities than in others. As, also, the principal evidence we have of the presence of this matter in the atmosphere, is its effect on man, it is not until an uninhabited district becomes inhabited, that proof is afforded of the extrication of deleterious substances from beneath the surface. These circumstances enable us to explain, why persons, who have fled from an infected town, have frequently been attacked *en route*, falling, as it were, into Charybdis while trying to avoid Scylla. It is commonly supposed, that the fugitives, in these instances, carried the germs of the disease with them: although precisely the same result is observed with those who come from an uninfected, as from an infected district.

Again: it is only by a reference to the theory under discussion, that the outbreak of disease on board ship, in particular instances, can be explained. Such a result has frequently occurred in mid-ocean, although the ship had not left an infected port, or the crew and passengers been within the focus of the disease previously. As, however, we find, that deleterious matters, derived from volcanic foci, escape from the springs that rise up beneath the waters of the ocean—as shown by their effect on the inhabitants of the deep—we have only to allow, that these

* *Statistical Report of Deaths in Madras*; for 1864.

matters are afterwards extricated from the surface of the water, and the cause of the outbreak is readily understood. It having been my object to show, on a previous occasion, that malaria is not absorbable by water,* if the gaseous matter productive of epidemic diseases possesses the same property, it would, instead of being absorbed by the waters of the deep, rise and become extricated into the surrounding atmosphere. That such is the fact, would appear to be conclusively shown by the following narrative, taken from the *Liverpool Times*. "When the Ann Bridson, which arrived in this port (Liverpool) from Valparaiso, last week, after a quick passage of eighty-four days, was off the River Plate, on her homeward voyage, the crew and captain suffered the greatest inconvenience from the state of the atmosphere, which, for two days, was so fœtid and offensive as to make it difficult for them to breathe; and we regret to say, that the effect of their exposure to this unwholesome air, did not cease when the atmosphere became pure, but continued to be felt during the remainder of the voyage—many of the crew having been ill from that time until their arrival in this port, and some of them being still much indisposed. Nothing was seen on board, which could enable the captain or crew to account for this unhealthy, or oppressive, state of the atmosphere; but the probability is, that the fœtid smell arose from a submarine discharge of gas, or vapour—a phenomenon which has frequently accompanied earthquakes and volcanic eruptions." The writer, after observing that pestilential gases were formerly given out from Lake Avernus and the Dead Sea, adds: "We feel little doubt, that the painful sensations, experienced on

* Vide *Causation and Prevention of Disease.* Properties of Malaria, page 89.

board the Anne, were produced by some sudden discharge of mephitic gas under the waters of the ocean, at the point which this vessel was then traversing." * †

The following anomalies are still more interesting and important. It will be found on investigation, that the pestilential principle, not only spreads from place to place, but that it is also progressive *in the same place*, being productive of different effects at different times. For instance, the plague was almost invariably ushered in by influenza, or measles, or anginas, and by intermittent, continued, spotted, or other fever, and by inflammations. Sydenham says: "I never knew pleurisies, quinsies, and other inflammatory diseases, more common than they were for some weeks preceding the plague in London in 1665." (*Opera*, vol. i., p. 122.) In May, a malignant fever appeared: it was the immediate precursor of the true form of plague. When this subsided in the autumn, the same fever re-appeared. The spotted fever, also, which prevailed so extensively in Europe, in the 16th and 17th centuries, was almost invariably the precursor of the plague, in which it generally terminated. Hence the remark of Van Swietan, that "the plague has sometimes lain concealed under the mask of other diseases": and hence, also, the fact, that the bills of mortality have invariably shown an increase—sometimes for two years—previously to the appearance of the plague. This was the case with the plague of 1625, when the total mortality in London rose from 8,500, to 11,300 in 1623, and to

* The *Times*, March 24, 1843.

† For an account of a remarkable outbreak of cholera on board two emigrant ships, at precisely *the same spot* on the ocean, but not at the same time, there having been an interval of some weeks between the sailing of the two vessels, see Chapter III., Part I., p. 222.

12,000 in 1624. This progressiveness in the pestilential principle is fatal to the doctrine of contagion; not only because the matter of contagion could only produce the same specific effects at all times, and under all circumstances, but also because the so-called contagious disease *par excellence*—the plague—would thus appear to be an effect of the same cause as that productive of the majority of diseases—some of which are universally allowed not to be contagious.* This is more particularly true with respect to influenza, which no one would even dream of considering to be contagious. Thus, the influenza of 1510 preceded the third visitation of the sweating sickness in England, and the plague in the North of Europe; during which the son of the King of Denmark was carried off. There were four other general influenzas during this century, each of which was followed by pestilence. The first appearance of the sweating sickness, on the Continent, was preceded by the influenza of 1551: and that of 1557 was followed by a visitation of the plague in Holland—5,000 persons having died in Delft alone. Another influenza accompanied the plague that prevailed in Spain, in 1564; and the last influenza of this century, that of 1580, preceded the outbreak of plague in France, during which 40,000 persons died in Paris. Influenza was also contemporaneous with the measles of 1580, 1675, 1732, 1743, and 1775; the small-pox of 1580, 1675, 1743, and 1803: and the nervous fevers of 1658, 1732, 1738, and 1775. In the nervous fever of 1732, "the symptoms," says Dr. Arbuthnot, "were so high in some

* It has been my object to show, in the First Part of this work, that the plague is only a severe form of intermittent fever, inasmuch as the two diseases, in certain localities, are found to merge into each other. If so, the plague cannot owe its origin to contagion, it being universally allowed, that intermittent fever is produced by another and a different cause.

as to produce a sort of fatuity, or madness." Horses were attacked at the same time, and generally before men. The influenza of 1762, which commenced in Dublin in May—a month later than in London—was accompanied by a fever which much resembled scarlet fever, excepting that there was no eruption. "In June," says Dr. Rutty, "appeared a bilious putrid fever, sometimes attended with petechia, but the miliary type was more frequent." *

Not only is influenza accompanied by fever, inflammation, and affections of the chest, but, also, by those of the alimentary canal. This was the case with the catarrh of 1658, which, says Willis, sent, "as if by some blast of the stars," was accompanied by a bloody flux. Similar results were observed in the years 1733, —43, —62, —75, —82 and 1803. The epidemic cholera, also, as already shown, has been preceded and followed by influenza, both in Asia and in Europe. In fact, there is hardly a disease, that does not, at one time or another, either commence with or terminate in influenza. As Dr. Thompson, in his Annals of influenza, has remarked: "The affinity of influenza to other diseases, especially to those of an epidemic character, is illustrated by numerous facts recorded in these Annals: such epidemics being nearly contemporaneous, and sometimes superseding, or being superseded by, catarrhal fever." If, however, we infer, that influenza is only one of a numerous class of diseases —all those termed epidemic—derived from the sâme root, and springing up from the same cause: and if we also allow, that this disease is not, and cannot be, produced or propagated by contagion, it follows, that all the other diseases, belonging to the same class, must also be produced by a different cause. These conclusions granted, there is an end of the contagious origin of diseases.

* *A Chronological History of the Weather and the Seasons.*

There is another circumstance of some importance as regards the elucidation of the present subject. This is, that the cause productive of influenza is the same now as at former epochs, for the symptoms are identical. As one writer, M. Delafond, has remarked, while referring to influenza: "Nothing can more forcibly prove the definite character of the influence, which produces the disease, than the similarity of the symptoms, during several centuries, and under such different degrees of civilization. We find the affection, in our comparatively luxurious days, manifesting the same phenomena as it exhibited, when the presence chamber of sovereigns was strewed with straw: the entrance of aristocratic mansions obstructed with decaying vegetable matter; and a lantern required at night to guide the wary steps of the citizen through the 'slabby streets' of the metropolis." The same remarks will apply to the majority of specific diseases—as small-pox, scarlet fever, plague, and the different forms of fever. The poison productive of them, therefore, as, also, its chemical properties and composition, must be the same now as at former epochs: and the process that gives rise to it, must be as regular and as uniform as that productive of prussic acid.* But a contagious matter would necessarily have become changed, during so many centuries, and after passing through the bodies of so many men. As it has not, we have another proof of the non-contagious origin of diseases.

Another circumstance is, that when the reigning

* These inferences are strengthened by another circumstance. The same remedy, according to my investigations and conclusions, is a specific, or antidote, in the epidemic cholera, and for the whole class of endemics. If for endemics, it will also be a specific for epidemics, both classes being evidently the product of one and the self-same poison. See *The Antidotal Treatment of Disease.*

epidemic appears in one locality, other and different diseases spring up in other places, situated on the same *pestilential line.* Thus, the great plague in Constantinople was contemporary with the fatal angina and dysentery in America, in 1751 and -55. In 1758 and -59, the measles in America were contemporary with, or, rather preceded, the extensive Levantine plague of 1760. Plague prevailed again in the East in 1781, and was accompanied by epidemics in America. And Webster adds: "One remark I will hazard on the strength of facts within the present century, (the 18th) that whenever malignant diseases prevail extensively in Europe and America, the plague rages in Egypt and Constantinople." (*Loc. cit.*, vol. 1, p. 346.) Sometimes, the pestilential principle, in one country, seems to expend itself chiefly on the brute creation; while, in the same year or succession of years, its principal operation, in a neighbouring country, is experienced by mankind. Thus, in 1712 and -13, the cattle in Italy, Germany, and other countries were suffering from a desolating murrain, while in Austria, Hungary and the East, the plague raged among men. So, again, in 1770, while the plague was raging in Turkey and Poland, a mortal distemper swept away the cattle in Holland, Flanders and England. In America, malignant fevers prevailed at the same time. We have here proof, independently of other arguments and conclusions, that all specific diseases, both in the human and the brute creation, owe their origin to the self-same cause; thus verifying the axiom of Sir Isaac Newton—"a multiplicity of effects, but a paucity of causes." Results like these would be perfect anomalies viewed by the doctrine of contagion, or by any other and previous theory: but they are readily explained by that under consideration, inasmuch as we witness similar phenomena in the physical world; or, a variation in the effects at different points of the volcanic line, at the same moment or nearly so.

Although it is unnecessary to refer to all the anomalies that belong to other theories, there is one, that well deserves consideration before closing these remarks. This is, that when some particular and previously unknown pestilence has sprung up, it is invariably accompanied or followed by other new diseases; while the intensity of those previously existing is increased. Thus, the plague, which first appeared in Europe in the 5th century, was followed by small-pox—a new disease—and, subsequently, by angina, erysipelas, leprosy, and the sweating sickness. The epidemic cholera, also, has been followed by diphtheria, typhoid fever and rinderpest; and by an increase in the frequency and malignancy of all other diseases. Referring to the year 1837, Dr. Law remarked: "If ever there was a time, when atmospheric influence forced itself upon our notice as an active agent, in producing and in modifying disease, it has been within the last few years. Within this period not only have we been visited (in Ireland) by diseases to which we had hitherto been strangers, but every known and familiar disease has exhibited itself under an aspect of malignity *quite new* to it. Thus, in addition to cholera and influenza, erysipelas, malignant scarlatina, and diffuse inflammation of the cellular membrane, prevailed to an unprecedented extent. The cases of small-pox now also crowded upon us, and it was now that fever began to prevail."* Although we might allow, supposing that diseases owe their origin to contagion, that one particular affection should spring up, and continue to prevail for a series of years afterwards; it will be somewhat difficult to understand, how a number of accidental circumstances should occur, pro-

* On Fever, in *Dublin Medical Journal.*

ductive of so many different effects at almost the same moment. Granting that the spread of pestilential diseases is due to contagion, they must have arisen, in the first instance, from some accidental circumstance—local or individual. As M. Trousseau remarks: "Spontaneous origin is then an incontrovertible fact, in the development of even the most contagious diseases. In fact, as contagion necessarily implies the presence of two persons—the one giving, the other receiving, the morbific germ—it is only a trite (*banale*) truth to say, that, with the first who was attacked with a contagious disease, the malady arose spontaneously: that it was entirely produced under the influence of causes, which are completely unknown to us."* Still more difficult will it be to understand, why the spread of a disease like the plague or the cholera should cause an increase in all ordinary diseases, even in that of intermittent fever, which is universally allowed not to be contagious; and which is known to be produced by a very different cause. Intermittent fever not only prevailed epidemically, during the whole period of the prevalence of the plague, but it has also been the accompaniment of the epidemic cholera in nearly all countries excepting England, where it has been replaced by typhoid fever. "Nothing," remark the writers of the Madras Report on the Epidemic Cholera, "is more common than to observe the raging of this disease together, and at the same time, with intermittent fever." In Spain, intermittents were so common, on the subsidence of the epidemic cholera, in 1834, that hardly a person was exempt in the Provinces of Valencia, Murcia and Andalusia. If, however, all these diseases be produced by one, and the same cause, it is not surprising, that they should prevail simultaneously, and in the same intensity.

* *Clinique Medicale.* Tom. I. Art. Contagion.

If, therefore, we are enabled to account for the production of epidemic diseases, in the manner now pointed out; and if we are also able to explain the principal anomalies that belong to other theories; all that remains, in order to complete the chain of evidence on this subject, is to show, that earthquakes and other effects of volcanic action invariably accompany or follow epidemic diseases, and that they prevail along the same route, or line of the earth's surface, as the latter. This will be shown to be the case in the concluding chapter.

CHAPTER II.

THE CAUSE OF BLIGHT AND PESTILENCE IN THE VEGETABLE KINGDOM.

VEGETABLES, as organised beings, are not only subject to decay and death from internal and individual causes, but they are also liable to be affected, the same as animals, by external causes—by those agents that produce disease and death in the human and in the brute creation. More than this, we shall find that, when pestilence reigns in the animal creation, it is always accompanied, preceded, or followed, by blight, or mildew, in vegetables. In all the great pestilences that have affected the human race, the pestilential principle has extended, as one writer has observed, to every principle of life. "The beasts of the field perish with deadly epidemics; the fish, at the bottom of rivers or of the sea, die or become lean and sickly; while corn is blasted on the most fertile plains, and the fruits in gardens and orchards wither, or fail to arrive at their usual perfection."* We find this to have been the case in the first precise record of pestilence that is extant: the plague of blotches and blains, the murrain in cattle, and the blight in corn having all visited Egypt in close succession, in the time of Moses. The same result must have been witnessed in Italy from the earliest date, the ancient Romans having, at the very time that they suffered so much from plagues and pestilence in man and beast,

* Ree's *Cyclopœdia*. Art. Epidemics.

consecrated a Temple to an imaginary God, whom they worshipped under the name of *Rubigus*. They also instituted festivals termed Rubigalia, in order to preserve their corn from the injurious effects of the mildew—*rubigo*. These invocations were useless, as blight not only prevailed in Italy from time to time, but in Europe also, to the end of the 17th century—contemporaneously with pestilence in man and beast. Abundant evidence will be afforded of this hereafter. It is only necessary now to add, that vegetables, according to Hoffman, were affected with mildew, in 1693, at the very time that the cattle were perishing by a pestilential disease. Ramazzini also speaks of a disease, which affected corn, fruit, and vegetables, while an epidemic was prevailing among men. It is, however, unnecessary to recur to former periods, we have had sufficient proof, in the present day, of the simultaneous appearance of pestilence in the animal and in the vegetable creation. Soon after the commencement of the present pestilential epoch, inaugurated by the appearance of the epidemic cholera, a disease—the potato disease—as new in the vegetable creation as the former was in the animal, suddenly sprung up, and spread over Europe and America. It was most destructive in all countries, but in Ireland, where this root is so extensively employed as an article of diet, it produced the most lamentable results—a famine, which was followed by fever, and by so great a mortality, that the population was sensibly diminished. As the history of this vegetable disease is much better known than that of any other, it will be more instructive to confine ourselves, at first, to a consideration of the phenomena, that have been observed during its prevalence and progress.

It may be as well to premise, that the principal diseases, previously noticed in the potato, are the curl, the blue pock, and the scab. It is unnecessary to describe the symptoms, or characters, of these diseases: it is sufficient to know, that they are merely local, or sporadic, prevailing only in particular localities and in isolated cases, and that they are entirely distinct from the epidemic about to be considered. This was a gangrenous affection, —at least on the first visitations of the disease—attacking all parts of the plant, but more particularly the tuber. The disease, according to Dr. Martius, to whom we are indebted for the first description of it, made its appearance in the tubers, either after they were stored in the pit, or else in the spring, when the sets were committed to the ground. In the former case, the pits, when opened, exhibited a greater or less degree of corruption—three parts out of four occasionally having become altogether useless; and of the residue, when planted, the greater part often failed entirely.

This vegetable epidemic first appeared in Germany, in 1830, and in Ireland and America, in 1832. In 1840, it prevailed again in Germany, and to such an extent as to cause very serious alarm, and even to threaten the total extinction of the potato. We also know now, that the crops in many other situations were affected at the same time, although, from the limitation of the disease in these instances, it did not then attract much attention. There is, in fact, no doubt, that it existed in the Island of Arran, and other parts of the highlands of Scotland, from 1839 to 1842, doing more or less damage yearly—not more than half an average crop having been saved during these years. The same observations will apply to many other situations, both in England and elsewhere. Nothing more was heard of the disease until 1843, when it re-appeared in America in a severer form, and prevailed to a much greater extent than before. During that and the subsequent year, it spread over the greater part of the United States and Canada, and then subsided. The epidemic, however, was not confined to this portion of the globe, for, in 1845, it re-appeared suddenly in Europe, and rapidly extended through Germany, Holland, Belgium, the northern parts of France, and the greater portion of England, Scotland, and Ireland. During the next year the disease again returned; being less severe, however, in the former countries than in the latter, while it extended to situations not attacked in 1845. From this time to the present, the disease has returned nearly every year, and, in some years, to almost the same extent, at least in England, as on its first appearance. As regards the last visitations, it is important to state, that the disease has not exhibited the same characteristics as in the former. Then, as is evident from the description before given, it was first observed in the tubers, after they were stored, or dug up; but, in subsequent visitations, the disease commenced in the herbaceous part of the plant, or the underground stem and root, and thence extended to the tuber.

Having thus briefly described the characteristic features of this singular epidemic, during its different visitations, and pointed out the important fact, that we have no evidence of its existence previously to 1830; and that it is, therefore, a new disease, a *nova pestis* in the vegetable creation; we may now proceed to a consideration of the probable cause, or causes, of its production.

Generally speaking, vegetable diseases have been referred to what is popularly known by the somewhat undefined term of blight, or mildew. This peculiar morbid condition is constituted of small parasitical fungi, which are numerous, and have received particular names: such as brand, bunt, rust, botrytis, oidium, &c. The term mildew, in all probability, was applied, at first, to those moulds which form white, mealy, patches on leaves; as for instance, on the maple, pea, and other leguminous plants. Different species and genera of plants have their own peculiar parasites: although, sometimes, they only infest one particular plant of a species. But although well acquainted with these effects, we are, unfortunately, entirely ignorant of the cause productive of them; so much so, that the Editor of the *Gardeners' Chronicle* has suggested the propriety of expunging the word from the language as a substantive term, and using it only in its adjective sense. For instance, when a tree or a number of trees, or the whole or part of a field of corn, put on a sickly appearance, and their leaves wither, or decay, we say that the trees or plants so affected are blighted. In this sense, there can be no misunderstanding, for it is evident that the effects then witnessed are produced by a something. But, when we say that the morbid changes are caused by a blight, we use a word without any meaning, for we know not the agent called into operation in these instances; nor do we even know the sense in which the term is understood by others. As the preceding writer justly remarks, "in the discussion of the subject, some mean one thing and some another. Some seem to have an idea of a material agency in blight; others seem to understand it in the sense of a mysterious something, quite unknown and quite undefinable." But, although ignorant of what blight really is, we are better informed as to what it is not. Thus, it is not, as some suppose, a sun stroke, for it more generally occurs during the night; nor a frost bite, for it as frequently arises in warm weather as in cold; nor a plague of insects, for the leaves are generally affected before these appear. Again; it is not caused by particular winds or by lightning, for it is observed during all states of the weather, the same in calm as in windy weather; at periods when there is no perceptible evolution of electric matter, and when the atmosphere is in a state of negative, as well as of positive electricity. Nor can fogs or mists, the favourite vehicle of blight, be the cause, for although the blue mist, like the evil spirit of the same hue, haunts the imagination of the farmer; and although these phenomena frequently prevail at the same time as the blights, it is no less true that the latter as frequently occur without the former being observed. Still, notwithstanding our inability to define blight, we know that, at times, some agent is called into operation which is productive of disorganization and of death to plants and vegetables. When, therefore, the haulm of the potato plant was attacked, during the late visitation, and when the effects observed were similar to those produced in the above instances; it was only natural to infer, that the cause was that termed "blight." But, then, the individuals who advocate this theory, have been unable to explain how the effect in this instance has been produced; for the opinions broached on the subject, like those on blight in general, are alike untenable and unsatisfactory. Many other theories, however, have been enunciated, and various attempts made, in order to account for the destruction of so large a portion of the crops of this useful, and, at present, necessary vegetable to millions of the inhabitants of these islands. There are only three, however, which would seem to deserve consideration at the present moment; the first being that which ascribes the decay of the tuber to constitutional debility, caused by overcultivation, or the wearing out of the races; the second, to the generation of fungi or parasitical and other insects; and the third, to an alteration in the seasons, or to some particular but inappreciable change in the constituent elements of the atmosphere.

With respect to the opinion, that the vitality of the potato has become exhausted from excess of cultivation, or old age, it is only necessary to observe that, independently of many other arguments, which might be advanced on the subject, it is now certain, that those roots which have been produced from seed, as well as the produce of sets brought from Peru and other localities, where the potato is indigenous, have been attacked with the prevailing disease to as great an extent as other plants. Besides, the disease frequently commences, either in the underground stem and root, or in the external parts of the plant, as the haulm—the reverse of what we should expect if it arose from constitutional causes. In addition to this, there can be no doubt, that other plants have been attacked with the same, or a similar, disease to that affecting the potato. Thus, in 1846, onions, beans, peas, and acres of pickling cucumbers, were attacked, together with a variety of other plants, as dahlias for instance; as also the turnips, in some localities, and, in France, the beet-root and carrots—the disease, according to M. Payen, presenting the same character as that in the potato.* But, what is most remarkable, is the fact of the nightshade family generally having suffered, and in a manner which bears particularly on the present question. Thus, not only the leaves of the solanum lancinatum, but the berries of the solanum dulcamara were, in many localities, destroyed at the same time as the potato. These plants being only supplied with fibrous roots, the disease could not, as Mr. Masters, who furnished these interesting facts, justly observes, commence in these instances in the tuber. The cause therefore, if not general, has not been confined in its operation to this single plant. As such, we

* *Comptes Rendus des Séances de l'Academie des Sciences.* Nov. 16, 1846.

will inquire, if the second theory referred to can afford us a more satisfactory solution of the question.

That the decay in the haulm and the tuber is produced by a fungus, would appear not only probable, but almost certain, on a superficial consideration of the question, from the well-ascertained fact, that a vegetable parasite, or fungus—called "Botrytis infestans"—is invariably discovered on the leaves and stem, at an early period of the disease; while a variety of the same species is also found in the decayed portions of the tuber. This circumstance alone, however, ought not to satisfy the mind of a diligent inquirer after truth; for having proof that parasitic plants are developed immediately after an organized being loses its vitality, we may conclude, that the production of the fungus is an effect, and not the cause of the decay.*

In fact, it is necessary "that the surface, upon which they (the fungi) are to develop themselves, must in general, if not always, be in a certain state of chemical decomposition (putrefaction or fermentation)."† Hence it follows, that they do not become developed at all the spots on which germs are deposited; while their growth, even in the animal tissues, indicates a certain morbid disposition. Were it otherwise, animals and plants would soon be destroyed, for the spores (or seeds) of fungi are so minute, so numerous, and maintain their germinating power so tenaciously against the common external agents, that, by means of water and currents of air, fungi would become universally diffused. But, independently of analogy, we have proof, from the microscopical labours of

* The fungal theory, as applied to the diseases of the animal creation, has been fully discussed in the first part of this work, Chapter I.

† *The Pathological Anatomy of the Human Body.* By Julius Vogel, M.D. Translated by Dr. Day.

several individuals, that the disease has manifested itself on the leaves, stem, and tuber, *before* the appearance of these parasites, or fungi.

As regards the influence of insects, the late Mr. Smee published a work with the express object of demonstrating, that a species of aphis—*aphis vastator*—generated in unusual abundance, had produced all the mischief. A similar theory had been before advanced by Mr. Barnes, of Sidmouth, who concluded, that the destruction of the potato crop was caused by an insect termed the potato thrips—*thrips minutissima.* But the justness of this conclusion has been denied by several writers, who state, that this insect has been found in great abundance upon the bines of sound potatoes; while others, and among them Mr. Curtis, remark, that on crops very much infected, few or no thrips could be found. To return, however, to Mr. Smee, and the conclusion he formed, that the "Vastator has been the sole cause of the disease." The author informs us, that the Aphides puncture the leaf, suck its juices, and thus cause either local or general death. "This removal of one portion of the sap destroys its proper qualities; it can no longer return the material for the starch or cellular tissue, essential to the growth of the plant. When the growth of the plant is arrested, the natural vital actions are impaired; and other actions, as those of putrefaction or inorganic change, take place; the plant ceases to live in different parts, and decomposition ensues."* But, if such an effect could be produced by such a cause, how does it happen, that the destruction of the haulm by early frost prevented the disease—a result recorded by Mr. Russell, secretary to the Agricultural Society, Fifeshire, and established by the testimony of a

* *The Potato Disease, &c.* Paragraph, 443.

number of individuals? That the mere destruction of the haulm, by these or any other insects, would not cause the decay in the tuber, we may also infer from the fact, that the cutting off or pulling up the haulm has frequently prevented the extension of the disease to the tuber. Mr. Smee it is true states, in another part of his work, that "when the insect has damaged the leaf of the plant, it (the leaf) is much influenced by wet weather; a shower of rain will fill the stems with water, and, in consequence of the solid portion having been taken away by the insect, the moisture cannot cause the rapid growth of the plant which should take place under such circumstances." This, however, is so gratuitous an assumption that it might, as the Editor of the *Gardeners' Chronicle* has quaintly remarked, be disposed of by a counter-statement, viz., "that when the leaf of a plant is injured by Aphides, the leaf is less influenced than before by wet weather." (Dec. 8th, 1846.) As the Aphides feed, according to the opinion of all entomologists, on the *fluid* matter alone of plants, contrary to the conclusion of Mr. Smee who states, that the *solid* portion is taken away, the assumed inference of Dr. Lindley is more likely to be true than that of Mr. Smee. Unless therefore it can be shown, that the puncture of the insect is poisonous, we should be unable to account for the destruction of the tuber by the above means. Such an inference, however, is negatived by the fact, that when the Aphides attack other plants, they do not cause their death, nor even the destruction of the leaves on which they feed. That these insects do not produce any *morbid* effect, even on the potato plant, we may argue from a circumstance mentioned by Mr. Smee himself. This writer states, that he found thousands of Aphides upon the leaves of the wild potato at Chelsea, yet these very plants continued sound up to the date of the above communication. Again; although there are 49 varieties belonging to the genus Aphis, which are found on different plants and trees, the Vastator attacks, beside the potato, turnips, beet-root, the carrot, the different Solani, various Cruciferæ, wheat, and Indian corn. How is it then, we would ask, that its ravages, during that visitation, were principally confined to the former root, and that the latter almost entirely escaped—particularly as Mr. Smee informs us, that "the potato is not the most agreeable food to the Vastator." The author has himself furnished the answer, for he states, that "this creature cannot well live upon a very vigorous plant," or, in other words, a healthy one—for the terms are synonymous. Hence we may infer, that the Aphides, like the fungi, cannot be the primary, or remote, cause of the disease. Whether their appearance upon the haulm of the potato, during the period referred to, was merely accidental; or whether it arose from the circumstance that they found there more congenial food than on other plants, are questions that do not affect the present inquiry—for coincidence is not cause. Were it so, we might, with the same justness, accuse the worms in a churchyard of being the cause of the loss of vitality in the bodies on which they prey. In an interesting paper on the above theory, in the *Gardeners' Chronicle* (Dec. 26, 1846), Mr. Phillips informs us, that having placed a leaf on which an aphis was feeding in a powerful microscope, he minutely examined the spot after the insect had been removed. "No puncture of the cuticle, or any discolouration or disorganization of that part of the leaf was observable, and I could discover no difference in the texture from that of the parts immediately surrounding it." In addition to this, its simple proboscis—the diameter of which does not exceed $\frac{1}{6000}$ of an inch—is, as this writer adds, all the means the insect possesses to commit the dreadful ravages Mr. Smee attributes to it. During these microscopical examinations Mr. Phillips discovered, in several plants of spinach, globular fungi at the base or root, and on which no aphis or external fungi could be seen; an effect that had been previously observed in the potato plant. Hence, as fungi cannot exist in a perfectly healthy plant, we have proof of an abnormal condition before the aphis appears. This writer concludes, therefore, that the aphis could not have caused the potato disease, and, further, that the aphis cannot destroy *healthy vegetation*. This inference appears to be confirmed by a singular fact. Mr. Phillips mentions, that he examined two crops of spinach, one more or less diseased, while the other was free. In the first crop the aphis existed; in the second, none could be found. This agrees with the observation of Mr. Smee himself, who informs us, "that a turnip, when it is growing very vigorously, seems, as it were, to throw off the disease—" or, rather, the insect. Besides, the proposer of this theory should have shown, that the aphis has been found, and in unusual abundance, in every locality visited by the disease. In the absence, however, of such proof, we may remark, it is not probable, that any insect could have been generated, in such numbers, over large portions of the terrestrial globe, without leaving other evidence of its existence, and without having been discovered by other observers. As Professor Low remarked, at a meeting of the Highland Agricultural Society, "it is impossible to explain, how the same kinds of insects should be generated, at the same time, in localities so distinct and dissimilar, as the sands of Southern Africa, the plains of Missouri, and the moors of Scotland." There is, in fact, no insect, the generation and existence of which is not dependent on heat and cold. Its simultaneous appearance, therefore, in such a variety of climates, was utterly impossible. Granting, however, for the sake of argument, that this or any other insect had been generated in sufficient numbers to produce the effects ascribed to them, and that the mere destruction of the leaf would cause the decay in the tuber; we should, even then, be at a loss to account for those cases in which the gangrene has commenced in the root, previously to the formation of the stem, or its appearance above the ground. In addition to this, in the first epidemic visitations the disease appeared either in the winter or in the spring, when the ravages from this insect cannot be experienced; for the aphis has not heretofore been observed before June, or in any numbers until July or August. Rejecting this cause, therefore, as well as the former, we will now regard the last of these theories, in order to ascertain if that will account for the production of this vegetable pestilence.

Some of the individuals who advocate this theory, consider that, in consequence of an alteration in the accustomed seasons, the tuber was imperfectly matured, and, therefore, more liable to run into a state of decomposition than at other times. "The cause of this decay," says Dr. Lyon Playfair, "is an imperfect formation of the walls of the cells in the potato, produced by the rapid growth at first, the imbibition of much water, and the absence of sun at the time when the plant most required it."* As also there was, according to the chemical investigations of this distinguished lecturer, as well as of other writers, an excess of water in all potatoes during the second epidemic, there appeared to be a strong foundation for this opinion. But a more extended inquiry, and the return of the disease in 1846, proved that the above cir-

* Lectures on the Potato Disease. *Journal of the Royal Agricultural Society*. Vol. vi. p. 532.

cumstances cannot be the cause of the disease. Putting out of the question altogether the fact, that this root thrives in nearly all temperate latitudes; in those characterized by an excess of moisture, or the reverse—great dryness—the disease not only prevailed during a season remarkable for the quantity of rain which fell, and the absence of the sun's rays; but, *to a much greater extent* during the subsequent year, when the temperature was high, the season dry, and the weather eminently favourable to the growth of tuberous-rooted plants. In addition to this, the season, in 1845, in the north of Europe, and in America, where the ravages of the disease were as great as in England, was warm and dry, instead of being, as in England, wet and cold. As such, if there has been an excess of water, not only in diseased, but, also, as Dr. Playfair, Dr. Ryan, and other investigators, have stated, in apparently sound potatoes, during the past two years, we must ascribe the alteration, not to the quantity of moisture contained in the atmosphere or the soil; but, to the same cause as that which produced the other effects, or the disease. Besides, these causes would not account for the first epidemic invasion, when the disease presented a different character. In this case, as we are instructed by Dr. Buckner, the water contained in the tuber was reduced to one-half; instead of being, as in the second visitation, two or three per cent. above the healthy standard. It was these circumstances, which caused the first epidemic to be termed the "dry gangrene," and the next, the "moist." The difference, in the two cases, may be accounted for from the fact that, in the first visitation, the disease attacked the tuber, after it had been fully formed, or solidified; while, in the latter, the plant had not arrived at maturity, and was full of juice, or sap. The excess or diminution of water, in these instances, was simply due to the greater or less quantity of moisture contained in the plant, at the time of the attack; and must therefore be regarded as an accidental effect, instead of an exciting cause of the disease. This theory, therefore, the same as the others, may be consigned to the tomb of all the Capulets.

We have thus arrived at the last item in the list of remote causes, which have been considered worthy of attention on the present occasion; and have thus been brought to a point where, according to M. Harting, the domain of Science ends. Facts forsake us, he adds, and hypothesis threatens to draw us into its labyrinth. In spite of this opinion from so high an authority, I shall venture into the mysterious maze, in the hope and confidence of being able to thread its devious paths; notwithstanding that the talents and the research of some of the most scientific men in Europe have been devoted to the subject; and notwithstanding it is now acknowledged, by those whose opinions are entitled to any respect, that the cause is not only a mystery, but that further research seems useless.

Now the first circumstance that strikes our attention, in this inquiry, is the apparent fact, that the cause productive of the disease would appear to be present in the atmosphere. Thus, the decay of the potato plant has, during some visitations at least, commenced in the leaves and stem—in that part, in fact, which is alone brought into immediate contact with the atmosphere. In addition to this, trees and plants of various kinds have been attacked at the same time, and exclusively in the leaves. This has been observed more particularly with fir trees in this country, and the Lombardy poplar in France. Fruit also of different kinds, as apples and pears, tomatoes, and the produce of a variety of plants, were affected both in 1845 and 1846—circumstances which oblige us to conclude, that the operating cause, in these instances, existed in the atmosphere. That the cause was the same as that which produced the disease in the potato plant, may be concluded from the similarity of the effects in both instances—the disease in apples, pears, &c., presenting exactly the same chemical and other characters as that in the tuber of the potato. In the next place, it has been shown, that the haulm of the potato, when shaded by other plants and trees, or even by a wall, has escaped the blight which destroyed the remaining part of the crop. In a communication to the Editor of the *Farmers' Journal*, we find it stated that, in Devonshire—where the phenomenon can be better observed on account of the number of trees, and the height of the hedges—potatoes under or near these were invariably sound; the disease re-commencing after the protection of the trees was lost, and at a distance of fifteen or twenty feet from the hedge. Again; on the property belonging to Lord Dunfermline, in Scotland, there was a field planted with potatoes, having a wall on the east side of it. The whole of the crop was more or less infected, excepting the *two ridges* next the wall, which showed no symptoms of the disease. Many other facts of the same kind have been recorded by different individuals, but it is unnecessary to multiply the examples. Similar results have been observed in those localities where that well-known but invisible agent—Malaria—abounds. Not only has the interposition of a forest, a mountain, or a high wall, been frequently sufficient to protect the inhabitants of a neighbouring town from the noxious exhalations of a particular marsh; but even a blind, or cloth, has sometimes been a safeguard to an individual exposed to the tainted atmosphere. In these instances we are certain, that a morbid agent is present in the atmosphere, for the laws regulating the extrication of malaria from the surface, and its diffusion in the surrounding air, are now almost as well known as the laws of gravity itself.* Looking therefore at the above facts, and reasoning from analogy, we may infer, that a deleterious matter is present in the atmosphere in the instances under consideration; and that to its presence there we must ascribe the blight, which has been lately observed in the vegetable creation. The following circumstance also appears to show, that the cause of the potato disease is atmospherical. "An experienced farmer," says the *Christian News*, 1851, "lately stated to us the remarkable fact that, in each of the years in which the potato crop has failed, he and all his neighbours had the greatest difficulty in gathering the butter, from the top of the milk, after churning. They could only do so by means of a search applied to the upper portion of the contents of the churn. This season has happily brought back their old experience of the butter collecting easily, in pieces, by the churning process, and so being, quite readily, gathered by the hand."

There are, however, certain facts, that would appear to negative this conclusion. For instance, potatoes have been dug up evidently decayed, before the haulm has manifested any appearance of blight; "and the disease, in many cases, was most virulent, where the stem and leaves appeared the healthiest and most luxuriant."† In other cases, as before remarked, the disease has commenced in the old sets, and in the young shoots, before they appeared above the ground. As atmospheric influence is here entirely excluded, it would appear that the disease, in these instances, either exists in the tuber, or else that it is produced from some peculiarity of soil. That it is not the

* See *Causation and Prevention of Disease*, pp. 76—87.

† *Transactions of the Agricultural Society of Scotland*. October, 1846.

former has been already inferred; it only remains therefore to ascertain, if the latter conclusion can be the correct one.

Had we confined our observations to the first visitations of the disease, we might have drawn such an inference; for its ravages were then not only, comparatively speaking, partial, but principally observed on particular soils. So also, in 1845, potatoes grown on clay, or rich, heavy loams, and in wet, low situations, suffered more than those on light, gravelly, or sandy soils, and upland or hilly districts. There was also an exemption with the crops on deep, peaty soils, or moss. The ravages of the disease, also, were less on poor lands than on rich ones. But, in the subsequent year, no soil was entirely exempt—the crops having suffered, if not to an equal, at least to a nearly equal, extent on dry and on wet lands; on drained and undrained, on poor and rich soils; in elevated and hilly, as well as in low situations. Difference of soil therefore, although it may act, possibly, in favouring the ravages of the disease in some cases, or preventing their extension in others, will never account for the origin of the pestilence. How then are we to reconcile these apparent contradictions? This can only be by supposing, that the agent is a gaseous one, and that, like malaria, it is, if not generated, at least diffused, in the soil in which the plants grow—being extricated, at particular times and under particular circumstances, into the surrounding atmosphere. Such a conclusion is the only one that will account for these anomalies, as well as many others, that have been already, and which will be hereafter, considered—anomalies that cannot receive elucidation from any theory yet proposed. If however we conclude, that the agent productive of the disease is extricated from the soil into the atmosphere, we can not only understand why the underground part of the plant should be attacked, either simultaneously with the blight of the haulm, or even before the latter; but, we can also understand, on the same hypothesis, why the lowest tuber—that furthest away from the over-ground stem, and, therefore, most removed from the action of the light and heat of the sun—should, as Dr. Playfair states, become soonest diseased. The question therefore arises, can the poison termed malaria—or some other, generated in a similar manner—be productive of the effects under consideration? If malaria be, as is generally allowed, confined to particular situations, as the marshes of our own country, and the swamps and jungles of warmer ones; and if it be, as is more generally concluded, the product of animal and vegetable decomposition, such an inference cannot be drawn: for we have witnessed the ravages of the disease in nearly all situations—in the best as well as in the worst drained lands; in rich and in poor soils; in those abounding in animal and vegetable substances, as well as in those in which decomposition did not, and could not, take place. Nor is there any other gaseous and poisonous substance, with which we are acquainted, that is generated on the surface, and extricated into the surrounding atmosphere over large spheres of the terrestrial globe. Whence then can the deleterious agent be derived? If unable to account for its production above or upon the surface, our only resource is to glance into the interior of the globe,—as we were obliged to do, while considering the causes productive of disease in the animal creation,—in order to ascertain if there be any process going on there, sufficient to account for the phenomenon. As the only subterranean process, capable of producing the effect under consideration, with which we are acquainted, is that known by the term "volcanic action," we are necessarily led to refer the cause of vegetable pestilences to this process, all other assigned causes having been shown to be insufficient for the purpose. That the cause of these general pestilences among vegetables is the same, as that to which similar affections have been ascribed in the human race, will be rendered more than probable by a further consideration of the subject.

It may be remarked, in the first place, that the potato disease would appear to have obeyed the same laws as the diseases of the animal creation: and, consequently, the same as those of volcanic action. Like the latter, it has been confined to particular lines of the earth's surface, at least during the first visitation, and when appearing in an epidemic form. As a correspondent of the *Hampshire Guardian* observed, although every variety of potato is affected, in some places one kind will remain almost free; while, in others, the crops of the same kind are nearly destroyed. "The same capriciousness in the propagation of the disease," says M. Gérard, "has been observed everywhere. Here a field is desolated by the scourge—a few paces farther on, another, placed apparently under precisely the same circumstances, remains untouched. Whole districts are spared—others are severely attacked."* The correspondent of an American paper states, that, in 1846, he travelled 600 miles in New England and in New York over distinct lines of road, and noticed carefully the appearance of the potato crops. "The disease," he adds, "seemed *to run in veins*, judging from the condition of the tops, and perhaps extended, in a greater or less degree, over about half of the territory traversed." † It is stated in the *Garden*, September 1, 1877, that "the potato disease has followed the track of the thunderstorms

* *Comptes Rendus.* No. 16, p. 919, 1846.

† *The Plough*, Dec. 1846, p. 815.

and heavy rains, which had recently prevailed, and the result is total destruction. There has been no attack so swift, so general, so complete, for 20 or more years. Large plots of potatoes, sound and healthy to-day, are converted into rotten stems and putrid tubers to-morrow. It seems as if the lightning, of which there has recently been so much, had run *across* the potato field, and scathed and destroyed the plants utterly root and branch." Lightning, however, will not account for such results as these: on the contrary, thunderstorms are more frequently beneficial than hurtful to vegetation, by destroying insects and rendering the air purer. In addition to this, we have observed precisely the same results, when there were neither thunderstorms nor rain, but the very opposite state of the atmosphere—heat and calm.

Another circumstance, characteristic of volcanic agency, was the regularity of the progress of the potato disease, both chronologically and geographically. Although travelling in general with great rapidity, the disease, nevertheless, was found not to appear simultaneously at the different spots visited; but to progress on regularly from point to point. Thus, a member of the poor-law commission, travelling in the north, remarked: "The progress of the potato blight is rapid beyond all conception. It seems as if travelling with myself, so suddenly does it appear in crops which had been sound and luxuriant, to all appearance, a few hours before." That the cause now named has produced the effects under consideration, we may infer, from the suddenness of the attack; the rapidity with which the blight spreads over a whole continent, or large tract of country; and the limitation of its effects in these instances,—all indications of volcanic agency.

In addition to these reasons, if the epidemic cholera be, as before inferred, an effect of volcanic action, we may conclude, that the potato disease is so also; for both diseases sprang up almost simultaneously; traversed the same lines of the earth's surface, at least in Europe and America—the potato not being cultivated in Asia; progressed in the same direction, and have obeyed the same laws: while the one, like the other, is a new disease. The connection, between the diseases in the animal and vegetable creation, was very apparent during the last pestilential epoch, numerous instances of which will be adduced hereafter. The following will suffice for the moment. Webster states, that the town of East Hampton, on Long Island, lost, in two or three years, 200 miles of hedge (prim)—a greater loss, says M. L'Hommedeau, in a paper published among the transactions of the New York Agricultural Society (part ii. p. 103), than if every house in the town had been burnt to the ground as no proper substitute for fences has been discovered. The English black thorn has been tried but has failed. "The cause of the death of the prim is not known, nor the precise time when it began. But, in Connecticut, the failure was observed about twenty-five years ago, between the years 1770 and 1777, *during the prevalence of the terrible angina and dysentery among men.*" And Webster adds: "It is remarkable, that these diseases among corn, fruit trees, and shrubs, have generally, if not always, appeared first on the Atlantic shore, and gradually extended themselves into the interior of the country" (vol. ii. p. 157)—precisely the course pursued by the diseases and the earthquakes of the last pestilential epoch. These conclusions granted, we may also infer, that the immediate cause of the potato disease, the same as that of the epidemic cholera, is the extrication of a poison from subterranean reservoirs into the surrounding atmosphere, along the lines traversed by this disease. The uniformity also of the disease, in all the localities visited by it,—extending over so many degrees of latitude—would point to some cause beneath rather than above the surface. Were not the agent a specific one, and generated in situations beyond the influence of external causes, we must suppose, that climate—as heat and cold, moisture and dryness—would have some influence upon it, and alter or modify its nature. But this has not been the case, for although the disease has varied in different visitations, it has not varied in different climates. If however we infer, that the poison is generated in subterranean reservoirs; and that it produces its effect, while passing through the strata of the earth, or immediately after it becomes extricated into the surrounding atmosphere; we can understand, why the same effects should be produced in all situations, in which the same cause is in existence.

The preceding inferences receive support from a phenomenon, that has been observed during the prevalence of the potato disease, viz., the simultaneous appearance of a fog, or mist. In Holland, a thick, stinking, and general, mist was observed immediately antecedent to the potato blight, in 1845. In France also, as we are informed by M. A. Petit,* it was generally remarked, that the disease commenced after a fog, which appeared on the 9th and 10th of August. In England, the same phenomenon has been observed in numerous instances. Thus we learn that, in the early part of August, there was not a diseased potato in the North Riding of Yorkshire. On the 25th and 26th, a very dense fog prevailed, and continued all night. "On the morning after the fog, the whole of the potato fields had precisely the disorganised appearance they have after a night of frost; they were green and semi-transparent. They soon became black, and the

* *Pharmaceutical Times*, September 5th, 1845.

disease followed in a few days." Although the plant put on the appearance of being frost-bitten, this was not the cause of the blight, for the "air," adds Mr. Milburn, "was not at all chill: on the contrary, the heat and closeness were most oppressive."* Again; "an intelligent countryman from Sanday," observes Mr. M'Invay, "tells me, that one day he observed a very dense fog resting in patches on certain parts of the Island (of North Ronaldsay). At times, it was so defined, that he could point out the exact measure of ground over which it rested. In passing, it fell down on his small farm, emittting a very unpleasant smell, exactly like the bilge water of a ship—a sulphurous sort of stench. The next morning, he noticed the leaves of his potatoes slightly spotted; in two days, the shaws began to droop and wither; and before ten days, not a shaw was in his potato patch, more than if it had been a bare fallow.†" It was also stated by many observers, that a few days before any disease appeared in the potatoes, a dense cloud, resembling in appearance a thick fog, overspread the entire country. It differed however from a common fog, or mist, being quite dry, and having a disagreeable smell. Lastly: a writer in the *Scotsman*, referring to the potato disease in Scotland, in 1872, remarks:—"It is a curious fact, that the first appearance of the potato blight, in this country, was preceded by a dense easterly *haar;* and on every occasion on which the disease has since spread to any very considerable extent, this dense fog was its foreruuner." If the fogs and mists, at these periods, be derived, as previously inferred, from subterranean reservoirs, we have additional proof afforded of the source, whence the poison productive of the potato disease is derived. Not that the fogs are the cause of the blight, as such an inference could not be maintained—

* *Gardener's Chronicle*, Nov. 14, 1846. † *Idem*, Sept. 5, 1846.

these phenomena being only observed to a partial extent, and in particular places. Their appearance is merely a proof of there being an unusual evolution of gaseous matter from the interior to the exterior; and, therefore, that other and invisible, but noxious, elements may be extricated at the same time. Still, there is evidence that fogs —ordinary fogs—do sometimes contain elements injurious alike to animals and vegetables. During the severe and unexampled fog that prevailed in December 1873, and when so many cattle were affected, while a certain number died, during the "Show" that was then being held in the Agricultural Hall, Islington, vegetables were found to be attacked at the same time. The Editor of the *Gardener's Magazine*, referring to this circumstance, remarks: —"The late fog has left its mark on the vegetable world, the same as on the higher organisms, although less distinctly and less hurtfully. The most striking and the most rapid effect of the fog was seen in the orchid house. Scarcely had the darkness cleared away, when the orchids, which were finely in bloom before the fog came, were found to be flowerless, flabby, and deficient of healthy greenness on their buds. As for the flowers, they were on the floor, and, in many instances, so far mildewed and soiled as not to be worth picking up. When a few days had elapsed, the camelias, which had been densely covered with swelling buds, began to shake them off, and, in the large houses, the old trees shed their buds, so that they fell like a shower of *green hailstones!*"

That vegetables would be affected by the presence of a deleterious substance in the atmosphere, we learn from experience; for a pure atmosphere is as necessary to the health of plants as to man himself. It is true that the gas, which is exhaled from man as excrementitious, and which, if inhaled in excess, would become deleterious, is actually necessary for the existence of plants. But then it does not follow, that other gaseous compounds should not be as injurious to vegetables as to the human species. Such we find to be the case, while, in some instances, the presence of certain deleterious substances in the atmosphere, which can be borne by man with comparative impunity, are injurious and fatal to plants and trees. A great number of plants cannot live in the smoky atmosphere of London, notwithstanding that it contains so large a quantity of the substance, or gas, from which they derive their food. The cause is, no doubt, to be ascribed to the presence of a minute portion of carburetted hydrogen, which, therefore, we may consider as a poison to the majority of plants. The same inference will hold good when this, and other deleterious, substances are applied to the roots; for a great many trees in Paris, and other large towns in France, have been destroyed by the leakage of gas pipes—as we find by the Report of M. Joubert and M. Pepin to the Academy of Sciences. In addition to this indirect evidence, M. Marcet has shown, by direct experiment, that the action of poisons on vegetables is very similar to that observed in the animal economy. This was found to be the case, not only with mineral poisons, but vegetable ones also. Hence, this experimentalist concluded, that there must exist in vegetables a nervous system, similar to that in animals.* But, what is of more consequence at the present moment, we also learn from the result of some experiments instituted by M. Macaire, that plants are destroyed when the herbaceous part of the plant is exposed to the influence of various gaseous substances. The gases used on this occasion were chlorine, the hydrochloric, the nitrous acid, and sulphuretted hydrogen.† M. Marcet also tried the effect

* *Annales de Chimie et de Physique.* Vol. 29, 1825, p. 220.

† *Ib.* Vol. XXXIX., p. 85.

of gaseous substances on plants, that had their roots placed in a reservoir, containing the particular gas to be tried; and from which the atmospheric air was carefully excluded. The kidney bean, or haricot, was that used on this occasion. The one immersed in nitrogen, began to droop almost immediately, and died in a short time; another, placed in carbonic acid gas, did not appear to feel any effect for two hours, when that also began to droop, and finally perished in about eight hours; a third, exposed to hydrogen gas, did not exhibit any injurious effect for six hours, and did not die until eight hours after; while a fourth, placed in atmospheric air, continued fresh for forty-eight hours. We have thus proof afforded, that various substances—mineral, vegetable, and gaseous—act as poisons on trees and plants; and that the effect is produced equally, whether the poisonous agent be brought into contact with the leaves or with the root.

That the late pestilence, in the potato crop, is to be ascribed to the operation of some deleterious agent, we may infer, not only from analogy, and for the reasons already stated, but, also, from the pathological phenomena presented to our notice on this occasion. In the first place, the disease, when present in the haulm, manifests itself by the appearance of small, brown, or black specks, which gradually spread over the whole leaf. Independently of their external appearance, similar to that produced by some acrid or poisonous substance, these specks, upon examination, are found to be occasioned by the disorganization or death of the cellular tissue—an effect similar to that produced by severe frost.* But the loss of vitality

* The reporters all concur, though expressing themselves differently, in describing the leaves as presenting the appearance which they generally do, after having been injured by severe frost.—*Transactions of the Agricultural Society of Scotland*, Oct. 1846, p. 439.

is not confined to the leaves, for the gangrene extends to the stem and the tuber. This is produced by the same cause; viz., the disorganization and death of the cellular tissue. "The primitive disease in the potato," observes M. Bouchardat, "has been caused by the death of the shoots; which death has extended to the periphery of the tubercle. This partial death is speedily followed by a spontaneous alteration of the albuminous matter, which imparts to the portions affected the characteristic yellowish, brown tint, similar to that which is the consequence of death by freezing, or any other cause."* Hence this writer was induced to attribute the disease, in 1845, to the cold fogs which preceded the blight in France. But cold, as before remarked, cannot be the cause of the evil, for the temperature in the subsequent year, when the same phenomenon occurred, was unusually high. Besides, the destruction of the stem, in other instances, by frost has actually preserved the crop. Nor, on the other hand, can we ascribe the disease in the tuber to the destruction of the haulm, or the stem, as the gangrene, in many cases, commences in the former before the latter. If however we conclude, as has been already done, that the blight in the haulm has been produced by the operation of a deleterious substance, present in the atmosphere; and if we further infer, that the agent is absorbed by the leaves; we can understand, why the destruction of this part of the plant should be, in general, the first effect observed; as also, why the cellular tissue of the tuber itself becomes ultimately involved. As Dr. Playfair has remarked, the point at which the gangrene usually commences, is at the junction of the tuber with the stem, or at the point where the air-containing vessels are most numerous; the progress of the disease in the tuber, being

* *Pharmaceutical Times*, September 5th, 1846.

along these vascular bundles, or along the course taken by the air.* In other instances, however, the disease commences in the root, or in the tuber; in which case, the morbid agent, we may presume, is absorbed, not by the haulm but by the roots — it having been already inferred that the poison is present in the soil as well as in the atmosphere. The only difference is, that the agent, in the one case, as we may infer, is absorbed by the leaves, and, in the other, by the roots: the gangrene spreading along the vascular tissue, in the latter instance the same as in the former. That the disease in the tuber is not produced from the mere extension of the gangrene along the stem or the roots, we may presume from the fact, that the decay sometimes commences by the vessels in *the centre*, instead of the circumference of the tuber. That the deleterious matter is absorbed, we may conclude, not only from the arguments before used, but, also, because we should be unable to account for the destruction of the cellular tissue in the tuber, except by the introduction of some extraneous substance—all the other causes that have been named being insufficient to explain the phenomenon.

There is also another circumstance which tends to show, not only that the above conclusions are just, but, also, that the poison is absorbed in the night, rather than during the day. M. Macaire ascertained, during the experiments before referred to, that a gas, which was sufficient, even in small doses, to kill a plant, exposed to its action during the night, exerted no influence upon it during the day, even when employed in much larger quantities. Now it is a remarkable fact, that the late blight in the potato crop has usually been observed on

* *Vide* Plate illustrative of these remarks in the *Journal of the Royal Agricultural Society*. Vol. VI., part 2.

the morning of some particular day; either after the appearance of a fog, or some other peculiar state of the atmosphere, which attracted attention at the time. Mr. Milne, a gentleman who made some extensive observations as to the state of the weather, in 1845, states, that the blight, then experienced, was the business of only *a single night*. As may be remembered, it has been inferred, in a previous part of this work, that the poison productive of epidemic diseases is not only present in the atmosphere, but, that its specific gravity is greater than that of atmospheric air. It will therefore gravitate to the earth, as soon as the rays of the sun are withdrawn. If we conclude, that the same agent, or an agent possessing similar properties, is productive of the potato disease, the reason why the haulm becomes so frequently affected, during the night, is at once apparent. There is another reason. During the day, the carbonic acid absorbed by the plant is decomposed; the carbon being assimilated, and the oxygen liberated. But, in the absence of light (which is the cause of the fixation of carbon), carbonic acid is given out, and oxygen is absorbed. If the same inference be drawn with respect to other gases, we can understand why they should be absorbed in the night, rather than in the day.

But it may be answered, if the effects under consideration be due to the presence of a deleterious substance in the atmosphere or the soil, why should the potato be, not the only but the principal plant that is attacked. This may be ascribed, in the first place, to the size of the haulm, and, in the next, to the organization and texture both of the stalk and the tuber—causing, in the former, a large extent of surface to be exposed to the contact of the atmosphere: and, in the latter, a predisposition, or susceptibility, to take on diseased action from any morbid cause. As the stalk and tuber of the potato contain, not only a larger proportion of water than most other plants, but a large quantity of loose cellular tissue, the presence of this spongy texture will cause the plant to absorb gaseous and other matter, both from the soil and the atmosphere, more readily than would otherwise be the case. The stalk of corn, on the contrary, is not only more compact, but is also defended by a coating of silicious enamel, which tends to protect it from the operation of such causes. When, however, blight occurs in the spring, it then attacks the young and succulent leaves, and the stem of wheat, the same as other plants. Although there has been no general blight, as yet, among the cereals, it is to be expected that they also will be attacked hereafter, the same as at former epochs. The malign influence, productive of disease among vegetables, would appear to attack by classes, the same as is the case in the animal creation. We have an example of this, in the earliest record extant of blight, it being stated, in the book of Exodus, "the flax and the barley were smitten, but the wheat and the rye were *not* smitten." The cereal crops were frequently blighted during the prevalence of the Black Death in Europe; although it has been stated, by several writers, that wheat had not been known to mildew in France until 1550.

That such circumstances are sufficient to account for the variation thus observed, we have lately had proof in the effect produced on a forest of trees, by the deleterious emanations from some alkali works. The owner of the estate, Sir John Gerard, brought an action against the proprietor of the works for compensation; and it was shown on the trial that, amongst the trees injured, the oak, the ash, and the larch suffered most: but limes, Spanish chesnuts, elms, alders, sycamores, and the beech were only slightly affected, while hazels escaped altogether. Now the oak, the larch, and the ash are, as the Editor of *The Gardener's Chronicle* has remarked, the most tender leaved of our forest trees, when the leaves are young; and it might therefore be expected, that they would be more easily injured by muriatic acid gas—the deleterious substance which is given out from such manufactories. The alders, on the other hand, are guarded by their glutinous varnish, and hazels and beech by their copious hairs. Sycamores, again, are naturally able to resist the sea-spray, which has an analogous action to that of muriatic acid—and hence their escape. We also find, from the experiments of M. Macaire, before referred to, that of a number of plants exposed to the deleterious action of different gases, some entirely escaped, while the remainder died. M. Vogel also ascertained, that particular plants resisted the action of various poisonous substances much better than others. Thus, the *Iris Germanica* lived for some time in a solution of copper, which quickly destroyed other plants—particularly the *Hesperis Matronalis*. "This," adds the above experimentalist, "may be ascribed to the compact tissue of the leaves, which appears to present an obstacle to absorption, as I only discovered a small quantity of copper in the tissue of the plant."* Precisely similar results were remarked during the fog of 1873, before referred to. In addition to the plants then mentioned, the thorns and wild roses felt the effect of the fog, and the great crop of wild berries that they carried were found for the most part on the ground beneath them. The hollies, however, were not at all affected. Not only has this variation been observed with other classes and other orders of vegetables, but even with the potato itself. Thus, M. Munter states, that the

* *Journal de Pharmacie*, Vol. I., p. 373, 1842.

loss among the kidney and sweet potatoes in one part of Germany was 100 per cent.; among the white (oblong) 75 per cent.: do. (round) 50 per cent.; red, 0. Although the variation here observed has not been general, still it is evident, by the remarks of many other writers, that potatoes with the thickest skins have suffered less than others. In 1875, when the disease assumed a somewhat different form, the disease, as stated by Mr. Shirley Hibbard, Editor of the *Gardener's Magazine*, in a letter to the *Times*, attacked principally, if not exclusively, "the fast growing and most spongy textured of the American sorts. . . . . The best English sorts have not taken the slightest taint, though growing on the same ground, and in close proximity to the diseased American." The exemption, therefore, of the majority of other plants and trees, from the pestilence that has attacked the potato, will not invalidate the conclusion which has been drawn, viz., that the agent productive of the disease is present in the atmosphere, or the soil in which the plants grow.

Although it appeared to be necessary to show, why the potato has been attacked so extensively, and in preference to all other plants, the truth is the influence of the morbific cause has not been confined to this one root. Independently of the effects previously described, the vine has been attacked, in all the countries in which it is cultivated —at least in Europe and in America—and to as great an extent as the potato. This vegetable epidemic was first recognised in England, and was described, in 1847, by Mr. Tucker, of Margate, who had noticed it two years previously. Hence its designation *oïdium Tuckeri*. The next account we have, is of its appearance in the vineries at Versailles, in the same year, 1847; after which, or in 1850, it attacked the trellised vines in France, the produce, in many places, being entirely destroyed. In 1852, it spread over the greater part of France, and thence extended to Italy, Spain, the Greek islands and Syria; in all of which countries it has returned, from time to time, to a greater or less extent, and more particularly of late years, causing great consternation by its destructive ravages. The disease has not hitherto been as severe and as general in other countries as in France, where it has prevailed almost every year up to the present time. It is said to have appeared in America, some years before it was observed in Europe; and to have attacked principally, if not exclusively, the vines of European origin. The disease has thus assumed the character of a true epidemic; and would appear to have been more prevalent during the past year than at any former period. In a letter inserted in the *Times*, (Sept. 3rd, 1879,) from its Geneva correspondent, it is stated: that "M. P. Demole, a gentleman of high scientific attainments, addressed, the other day, a letter to the *Journal de Genève* in which he draws a graphic picture of the progress of the pest in neighbouring countries, and predicts its approaching invasion of the Valley of the Leman. All the hopes expressed, a year ago, that the propagation of the insect* might be checked by atmospheric changes, or a radical cure for its ravages discovered by science, have proved illusory; the plague continues, and the outlook is decidedly worse than it was this time twelve months. The south-west of Portugal has been attacked over a wide extent of country, and especially in the Valley of the Douro. In Spain, the phylloxera has been found in more than 100 places, and in the province of Malaga alone upwards of 2,500 hectares (6,250 acres) are affected. The Spanish and the Portuguese insect differs from its congener, north of the Pyrenees, in that it is larger, stronger, and

* The *phylloxera*, an insect to which the disease is now attributed.

generally of a more robust constitution, and likely, therefore, to be more destructive, and less easy of extirpation. In Italy, the phylloxera (or, the disease) has appeared at Vintimiglia (and, according to a telegram received yesterday, its presence has just been detected in the province of Como); in Austria, it has shown itself at Klosterneuberg; in Hungary, at Panscova; and divers parts of the German Empire, where, however, as yet, it does not seem to have done much harm; while its ravages in France are fast attaining the proportions of a national calamity. Of very evil augury is the appearance of the phylloxera, as lately notified, at Amareus, in the Tarn. This event signifies nothing less than the union of the two grand invading armies of insects, which have been so long preying on the vineyards of France. The hosts that, since 1865, have occupied the valley of the Rhone were, to all seeming, quite distinct from those which had settled in the valleys of the Garonne and the Dordogne; but now they have joined hands in the Tarn, and the whole breadth of France, from the south-east to the south-west, is in possession of the enemy. The populations who depend on vine culture for their living are in a state of great discouragement; in many districts, they have abandoned the contest in despair. In the Charente-Inférieure 396,750 acres of vineyards are either destroyed or phylloxerated. Out of 422,362 acres contained in that department only 36,612 remain unaffected. The devastating hosts are advancing on Western Switzerland from two sides—from Savoy, and the department of the Ain; and it is also threatened, though more remotely, from the departments of Saone-et-Loire and the Côte-d'Or. In Savoy, there are at least 50 centres of infection, while in the Côte-d'Or and Saone-et-Loire the pest seems to have become more firmly established every day."

The symptoms of the disease are as follows:—The first apparent sign in a vine, of the approach of the enemy, is a spot on the leaves, which has been compared by M. Bazille to the mark left by a drop of oil—*la tache d'huile.* In the midst of strong and healthy plants, five or six are perceived to be of a yellow tinge; a greater number then present the same aspect, those in *the centre* being in a worse state than the others. The leaves lose their green colour, dry up at the margin, and the grapes do not arrive at perfection. The following spring, the stems, instead of giving branches four or five yards in length, only produce shoots the half, a third, or a fourth of the usual size. During this interval, the disease gains ground and extends, but *always in a circle.* This progression takes place either very rapidly and sudden (*d'une manière foudroyante*), destroying, in six months, the finest and most healthy vines; or more slowly, and in a less destructive way. The fact the most lamentable, and which has never been observed before, in any disease of this plant, is the death of the stem. When a plant, already affected, is taken up, in the month of June, in the full vigour of its growth, the root fibres, instead of being thin and cylindrical, exhibit here and there, and particularly at their extremities, a peculiar swelling: it is a local hypertrophy. Towards the end of the summer, these swellings become black and gangrenous: the disease spreads gradually along the roots, and the plant perishes by degrees.

Like the potato disease, no satisfactory explanation has been afforded, at present, of the cause of this vine pestilence. Mr. Tucker and others ascribed it to mildew, and hence its designation, at first, *oïdium Tuckeri.* In France, it was generally referred to the same cause, during the first years of the prevalence of the disease, or until 1863. In a communication made to the Academy of Sciences, Paris, (*Sèance*, Sept. 2nd, 1850), M. le Dr. Marie remarks: "This leprosy of the vine is caused by the *oïdium leuconium*, being the same as that which attacks rose trees, and commonly called *le blanc*." A few writers, however, concluded, that the *oïdium* was not the cause, but an effect of the disease. Thus, M. Camille Aiguillon having stated, in a memoir presented to the Academy of Sciences, Paris, (*Sèance*, Jan. 17, 1853), that he had observed some grapes entirely exempt, while others, close to them, were covered with *oïdium*, M. Guerin-Meneville, in a note appended to the above memoir, concludes: (1) That the development of the *oïdium Tuckeri* is the consequence of an abnormal state of the vine: (2) That the disease cannot be communicated to healthy plants by the spores of the *oïdium*. And M. Fox, in a note to the Academy (July 4th, 1853), states, that he considered the disease to be caused by an insect, a species of acarus—the *oïdium* being developed subsequently. M. Destigny, also, in a communication made at the following *Sèance*, attributed the disease to another insect, which he does not name, but a specimen of which he sent to the Academy. No other cause was assigned for the origin of this singular malady until 1863, when a particular insect having been discovered on the roots of the diseased plants, the conclusion was at once drawn, that this insect—the *phylloxera vastatrix*—was the cause of all the mischief. This conclusion appeared to be confirmed by the fact, that the swellings on the root fibres, before described, are evidently caused by the puncture of this insect, one being generally found inside.* This grub was first observed, on diseased vines,

* The *genus phylloxera* belongs to the Aphis tribe, and is said to be common in America. In Europe, there are the following species, viz. P. *quercus*: P. *coccinia*: P. *corticalis*: P. *rhizaphis* or *vastatrix* (*puceron*, or louse of the vine). The last lives both above

in America, in 1854, by Asa Fith; in England, in 1863, by Westwood; and, in the same year, in France, in the Departments of the Gard, Vaucluse, Bouches-du-Rhone, Ardêche, Herault, etc., but not until 1869 in the Department of Gironde, and the environs of Bordeaux. As, however, the disease had existed in France from 1850, it seems difficult to understand, if it were caused by the ravages of this insect, why it was not discovered before. As regards the simultaneous appearance of these insects and the disease, no deduction can be drawn from this circumstance; as there can be no doubt, that the state of the air, at pestilential periods, is favourable to the generation of insectile life. Of this truth, we have proof from the earliest records; locusts and swarms of flies having been the accompaniment of the plagues in Egypt, in Moses' time. The same phenomenon was remarked during the whole of the last pestilential epoch, and has been recorded by all writers. Myriads of flies, worms, and other noxious insects, accompanied the pestilences and plagues that prevailed in the years A.D. 763, 1001, 1106, 1234, 1286, 1348, 1390, 1575, 1598, 1610, and 1612. The principal locust years have been B.C. 206 and 174, and A.D. 394, 590, 677, 1031, 1084, 1091, 1186, 1234, 1337, 1476, 1646, and — 47. Aristotle mentions an increase in the number of frogs as indicative of sickly years; and Horstius states, that an unusual number of locusts, cankerworms, frogs, toads, mice, and snails, are the infallible signs of a pestilence. To these, he adds an extraordinary abundance of fish in the sea, and in the rivers (*De peste*, p. 253). The same remark has been made by other writers, as regards the

and beneath the surface: but the typical insect—that of the oak—has an existence exclusively aërial. The underground insects are supposed to be the females, some of which, however, afterwards become winged.

abundance of fish, at pestilential epochs; while a similar phenomenon has been observed in the human race—not before, however, but after the prevalence of pestilence. These facts show, that there are other elements generated and diffused in the waters and in the air, at pestilential epochs, besides those productive of disease and of death. Hence it is, that, in addition to the *phylloxera,* other insects were discovered on the roots of diseased vines. Instances of this have been already given; and M. Schnetzler states, that he found, beside fungi, other organisms, such as *tyroglyphus,* an insect of the acarus tribe;* *anguillulæ* (microscopic eels), and *bacteria,* on the roots of diseased vines. But the disease was not ascribed to the ravages of these insects: why, then, to the *phylloxera?* There are many reasons which forbid our drawing such a conclusion.

In the first place, there is no evidence to show, that the phylloxera can produce the death of the plants on which it feeds. The phylloxera is not a poisonous insect, nor has it sprung up suddenly, like the armed men of Cadmus, to commit havoc and destruction among the vine plants. On the contrary, the genus phylloxera has been long known, particularly the phylloxera *du chêne,* which is very common in the South of France; but we have never heard of any injurious effect being produced on this tree or on other plants, beyond the production of gall-nuts; and this effect is entirely local. It is true, that the *phylloxera vastatrix* attacks the fibres of the root, producing the same effect on them as on the leaves of the oak, viz., a swelling or excrescence; but it is hardly possible to believe, that this effect could be productive of disease in the whole plant, and its subsequent death—more parti-

* This insect is the natural enemy of the phylloxera, and is often found waging a vigorous war against it.

cularly if it be the fact, as stated by M. Max Cornu, in a memoir read at the Academy of Sciences, Paris (Dec. 16, 1872), that this insect does not live on the sap of the vine. This writer remarks:—" The destruction of the plant is not produced, as is so often said, by the abstraction of the sap by the phylloxera (the vine at the time of cutting frequently loses a good deal of juice without suffering in consequence). This insect cannot, with its proboscis, which only penetrates the root to a third or the half of its length, reach the vessels of the plant, as I have been enabled to ascertain. It could only reach the vessels of the lower fibres, possessing a diameter of the half of a millimetre." Hence M. Max Cornu is induced to conclude, that " the morbid effect is due to the formation and the nutrition of the swellings, which absorb the nutritive juices destined to other purposes, and turn them from their natural destination." But no such effect is observed on the oak, or even on the vine, in certain cases, for although the phylloxera only attacks the roots of French vines, it produces excrescences on the leaves of American vines. And yet, it is these very plants, which differ somewhat from the indigenous vines of France—being more vigorous and hardy, and producing a poorer wine—that continue exempt, when the latter are attacked, although in close proximity. There is, of course, a difference between the root and the leaves, as regards their functions; still, if this insect could produce such disastrous results on the fibres of the root, some morbid effect ought also to be observed on the herbaceous part of the plant. But none occurs; although, according to M. Dumas and others, all doubt, respecting the identity of the phylloxera of the root and of the leaves, has been entirely removed. Observing this effect, M. Laliman, of Bordeaux, has proposed to replace the indigenous vines of France by those of America. Knowing, however, that epidemic diseases invariably attack by classes, in the vegetable as well as in the animal creation—selecting the weakest first and the strongest afterwards—it is probable, that these plants would hereafter become affected, while the others remained exempt. This conclusion would appear to be confirmed by the following circumstance :—In a letter addressed by M. J. B. Schnetzler to M. Dumas, it is stated, that M. Nordlinger, Professor of the Academy of Hohenheim (Wurtemberg), discovered in the neighbourhood of Stuttgart, three centres of the invasion of the disease: two, in the royal villa of Wilhelma, and a third, in the royal villa of Berg. The vines attacked were all American: and had been imported, ten or twelve years before, either directly from America or from France. The phylloxera was found on the roots, and particularly on the fibres of the root: and they had caused the same swellings as on European vines.*

That the vine disease is not caused by the phylloxera, may be inferred from the following circumstance. It is stated, in a letter addressed by the Chamber of Commerce of Bordeaux to the Minister of Agriculture and Commerce, in August, 1876, that "in the Department of the Gironde, the phylloxera has shown itself in many places, where it had never before appeared; and that it has assumed a character of much greater intensity." † If, however, the vine disease were caused by the ravages of this insect, it is difficult to understand how these districts could have escaped so long, being in close proximity to those that were severely scourged.‡ Another circumstance

* *Comptes Rendus.* Vol. 83, 1876, p. 535.

† The term phylloxera is sometimes employed, by French writers, to designate the disease as well as the insect.

‡ The phylloxera passes from one plant to the other in several ways. (1) On the surface of the ground. (2) By the hollows beneath the surface, following the sinuosities of the roots. (3) Through the air, as winged insects.

is no less conclusive. The disease has sometimes sprung up suddenly, and spread with great rapidity. This was the case in 1870, in the valley of the Rhone, and in the Department of the Gironde. According to the Reports of the *Société des Agriculteurs*, "the symptoms were identically the same everywhere. Healthy plants died off suddenly, without any apparent cause; the stems turned black; the leaves faded and dropped off; and close examination showed, that the roots were rotten throughout." This, therefore, could not have been caused by the phylloxera, as, independently of the fact, that no mention has been made of their presence, the attack was too sudden and too rapid, to have been produced by such a cause. It was considered to be a new disease, but there was nothing new in it, excepting in the suddenness of the attack: for the pathological state of the plant was the same as in the previous visitations—the root being the principal seat of the disease. Another, so-called, new disease in the vine made its appearance, in 1877; and has been described by M. Schnetzler, in a Paper addressed to the Academy of Sciences, Paris. According to this observer, the disease, which was then spreading over Germany, Switzerland, Savoy, and other parts of France, "consists of myceliums (threads) of mushrooms, that invade all the underground parts of the plant, causing, in a short time, the decay of the branches, and the withering of the leaves, and, ultimately, the death of the whole stock." The mushroom family are represented by myceliums of *Mucor Penicillium*, and *Rhizomorpha;* the latter being merely a transition stage of other fungi, of the genus *Agaricus*. These fungi on plants look like white spots, and hence the designation—*le blanc*; and M. Schnetzler adds: "In the form of the disease, known by the name of *le blanc*, I consider the *Rhizomorpha* as the principal cause of the evil." This, as will be evident, is precisely the form that the disease assumed at its commencemeat, and for many years after—long before the phylloxera appeared. To call the disease, therefore, a new one, merely because fungi made their appearance on the diseased plants, would be to ignore the existence of the pestilence for the previous fifteen or twenty years. More than this, the pathological state of the plants, in the above instance, was precisely the same as when they are attacked by the phylloxera. How, then, is this result to be explained? Are there two causes in operation, productive of precisely the same result? That must be the case, if the conclusion of M. Schnetzler and other writers holds good: but that is not probable, nor, in this instance, possible, as fungi do not "cause the decay of the branches, the withering of the leaves, and, ultimately, the death of the whole stock": they would not have appeared, unless some morbid change had taken place previously in the plant. This conclusion is apparently confirmed by the results observed, in the instance before given, when the American vines were attacked in Germany. According to M. Schnetzler, "ten different varieties were attacked; but, among these, the Isabella vines remained entirely exempt; although *the fibres of its roots were intermixed* with those of the variety called 'Concord,' which was covered with the phylloxera." With these facts before us, we are warranted in concluding, that the phylloxera, like the fungi, are an effect, not the cause, of the disease: and that their appearance on vines, of late years, is to be ascribed to the circumstance that they found there, in consequence of the disorganization of the plant, more congenial food than could be obtained elsewhere. Among all the numerous communications addressed to the Academy of Sciences, Paris, there is only one writer, as far as I am aware—M. F. E. Guerin-Meneville—who has ventured to oppose this insectile theory. He remarks: "The study I have made of this new form of disease of the vine, regarding it not only as naturalist, but more particularly as agriculturist, and over extensive districts, confirms me in the opinion that I expressed at first. Thus, as I then maintained, the excessive multiplication of the phylloxera is a phenomenon consecutive to the disease of the vine. It appears to me evident, that the vines are attacked with a disease that may be compared to a scrofulous affection: to the pedicular disease among men, or to the invasion of parasites observed with animals more or less diseased." * This is the only way in which we can account for the circumstance before mentioned, viz., that the phylloxera has not been observed in certain districts until lately, although in close proximity to those that had been ravaged for years. The vines had not been previously brought under the malign influence of the cause productive of the disease. If, however, this disease were caused by either insects or fungi, it is altogether unlikely, that these districts should have been spared thus long; for while the multiplication of the one is unlimited, whenever food is provided for their sustenance, the spores of the other float constantly in the atmosphere, ready to settle on any substance, that can afford them life and sustenance. Referring to the fungus, that attacks corn, called "smut," "burnt ear," "black ball," "chimney sweeper," &c., on account of its appearance—that of black dust—Mr. Cook remarks: "The spores in this species are exceedingly minute. It has been ascertained, that forty-nine of them would be contained within a space the 169,000th part of a square inch: hence one square inch of surface would contain little less than eight millions." † For every ear

* *Comptes Rendus.* Vol. 75, p. 684. † *Microscopic Fungi.*

of corn that had become smutted, ten millions, at least, of spores would be dispersed in the surrounding air.

Having thus attempted to show, that the causes hitherto assigned for the production of the vine disease, are insufficient to account for the phenomenon, the question arises, what is the real cause? That the cause is a general one, must be apparent from what has gone before, independently of the fact, that the morbid effect has not been confined to this one plant; vegetation in general having been affected, to a greater or less extent, at the same time as the vine. M. Marie remarks that, in 1850, a variety of plants, that he names, were attacked with the *oïdium;* and, consequently, with disease. And M. Guerin states, as the result of his observations, in 1853, that the epidemic spread, not only to the vine and the potato, but to the artificial grasses, particularly sanfoin; the cereal crops; melons; gourds; tomatoes; roses; mulberries; nuts; and other fruit trees. In the next year, carrots, potatoes, beans, nuts, and corn, were likewise attacked. And M. Schnetzler observes, that he has seen whole plantations of peaches perish, in 1877, at the same time as the vine; and that they were covered with the same fungus. In Greece, the currant trees were affected as well as the vine. What, then, is this general cause? Remarking, that this is a new disease; and that it has sprung up since the advent of the epidemic cholera, and contemporaneously with the potato disease; we are at once led to inquire, whether it is not produced by the same cause as these epidemics. That it is, we can hardly fail to infer, when we find, that all three diseases have appeared almost simultaneously; have obeyed the same laws; have progressed along the same lines of the earth's surface; and in the same direction, or from north to south.

Like human diseases, the ravages of this vegetable pestilence have been greater in some districts than in others, possessing a different geological formation. This was the case in 1870, when certain districts, on the right bank of the Rhone, escaped altogether; while "on the left, which possesses a different geographical (*i.e.*, geological) conformation—wide plains and valleys watered by numerous streams—the disease had been almost universal."* The variation must be ascribed to the greater or less facility with which gaseous matter escapes from the interior to the exterior, according to the nature of the soil—a conclusion that would appear to be confirmed by the following circumstances. M. Duclaux, Professor at the Faculty of Sciences at Clermont-Ferrand, has endeavoured to ascertain the circumstances that favour the spread of the vine disease; and he has arrived at the following conclusion. It is this: "That the rapidity of the progress of the disease depends, all other circumstances being the same, almost entirely on the physical condition of the ground, or the surface. The insect (or rather the disease) spreads more rapidly in cracked and fissured ground than in a close, compact soil. In the Crau d'Arles, where the ground is formed of ancient alluviums of the Rhone, and composed of loose flints with a small quantity of mould, the disease progressed rapidly, and presented numerous, malignant *(foudroyants)* cases—followed by the speedy death of the vine. In good soil, on the contrary, neither too stony nor too clayey, and which does *not crack* during summer, the disease spread more slowly, as also, in sandy soils."† Another circumstance leads to the same conclusion. M. Robouam, in a communication to the Academy of Sciences, Sept. 13th, 1852, states, that the branches of his vines, which spread themselves over the grass, remained sound; while those that were trained over ploughed land

* *Rapport de la Société des Agriculteurs.*

† *Dictionnaire Universel du XIX Siècle.* Art. Phylloxera.

were all diseased. He has, therefore, recommended that the ground in vineyards should be covered with grass, or other close growing plants. Many other circumstances have been adduced, by different writers, all of which lead to the conclusion, that the disease spreads more rapidly in loose than in compact soil. Hence M. H. Marès, in a paper read at the Academy of Sciences, has concluded, that "cultivation exercises on the vine an action directly favourable to the multiplication of the phylloxera;" or, more correctly, to the spread of the disease. And he adds: "By the sides of our vineyards, and on the same soils, there exist, we may say generally, plants that are derived from either wild or cultivated vines, and which grow in uncultivated ground; the immunity of which from the attacks of the phylloxera, has often attracted the attention of observers. I have considered them, since 1868-9, as possessing a particular interest. Not only do they continue to vegetate and to fructify, by the side of vines that are destroyed; but it is the same with those which are situated on the high roads and on grass lands, alongside vineyards that are devastated; in a word, they find conditions favourable to their preservation, in every situation in which their roots can penetrate a soil always *firm and solid.* Nature thus places before our eyes, and often on the same soil, cultivated vines which perish, and wild ones which continue sound." The writer also states that, on the Mediterranean coast, of France, the lands, which are principally devoted to the pasturage of cattle, are also planted with vines. "Certain portions of these vines have, for nearly 50 years, been left entirely to themselves. These plants are not dead; they flourish vigorously; and yet, at only a few yards' distance from them, the same *cultivated* varieties (aramons, carignanes, tersets, espirans, piquepouls, &c.) are devastated, and perish under the attacks of the phylloxera. . . . It is the same with trellised vines, when planted in close ground, *well trodden down.* They have been thus preserved in Provence and Languedoc, in numerous localities, in which the cultivated vines perished phylloxerated."* M. J. François, in a note addressed to the Academy, also remarks: "A fact, generally recognised at present, is this: that the disorganization of a vine when attacked, all other circumstances being the same, is so much the more rapid in proportion as the surface of the ground is turned, or worked. The facts that can be produced, in support of this conclusion, are sufficiently numerous to be made the basis of an antiphylloxeral mode of cultivation":† and if of an antiphylloxeral, of an antipestilential method. Another fact is also worth recording. M. François adds: "I had remarked, since 1873, that the invasion of the phylloxera appeared to be lessened by the intercalation between the vines, of portions of ground devoted to other cultivation:" and some writers have stated, that the planting of maize and other plants has appeared to prevent the ravages of the disease. The cause of the exemption in these cases will be readily understood by a reference to what has gone before: it is not because the roots are less luxuriant and the fibres less numerous in hard, compact ground, as some writers infer; or because the phylloxera attacks the maize, in preference to the vine, when the ground is covered with this plant, as others conclude; but merely because exhalations from the surface are prevented, to a greater or less extent, in both instances. That the disease is caused by the extrication of a deleterious substance from the interior to the exterior, may also be inferred from the manner in which the disease spreads in a vineyard, or in a district. This, as previously mentioned, is invariably *in*

* *Comptes Rendus.* Vol. 82--1876—p. 958. † Id. p. 1147.

circles from given points,—precisely the result we should expect, if the disease be produced by the evolution of gaseous matter from the surface, along a particular and well-defined line. It is, besides, indicative of volcanic action; the effects resulting from earthquakes frequently presenting the same phenomenon.

It is only on this hypothesis—the evolution of gaseous matter from the surface, and its greater facility of escape in one situation than in another—that will enable us to explain the immunity of Switzerland, which, with the exception of a slight visitation in 1877, at Chambery, has hitherto escaped the ravages of this vegetable pest. It may not, and probably will not, escape hereafter: but its invasion then will only show, more closely, the analogy that exists between the pestilences of the animal and of the vegetable creation—Switzerland, as may be remembered, having been the last country, in Europe, visited by the epidemic cholera.

That the cause now assigned for these vegetable epidemics is sufficient for the purpose, we have proof from the fact, that the destruction of the surrounding vegetation is a common result of volcanic eruptions. The vapours given out during the eruption of Mount Vesuvius, in 1794, destroyed all the vegetation in the neighbourhood, excepting the olive and the pear trees. The same result is observed after earthquakes. "During my abode in Peru," remarks Humboldt, "the herbs, that cover the savannahs of Tucuman, acquired, after violent earthquakes, noxious properties; and an epidemic disorder took place among the cattle at the same time. A great number of them appeared stupefied and suffocated by the deleterious vapours exhaled from the ground." We have here a good example of the simultaneous affection of animals and vegetables, and by the same cause—that which it has been the purport of this chapter to demonstrate, viz., volcanic action. Tradition also says, that wheat has never flourished on the coasts of Peru, since the earthquake there in Oct. 1689.

This forms the last link in the chain of presumptive evidence, which has been advanced, in order to prove, that the blights, or pestilences, in the vegetable world are the effect of volcanic action. As the chain is thus complete, and as the links would appear to be bound inseparably together; it is to be hoped, that they may be able to bear the strain, to which they will be subjected by other theorists, and by those modern Goths and Vandals—the critics—whose chief employ, apparently, is to pull down and destroy what others build up. When, however, we find, as will be demonstrated hereafter, that pestilence in the vegetable creation has invariably been observed at all epidemic periods, contemporaneously with that in the animal creation; and that the intensity of the one has been in exact ratio with that of the other; while both have been accompanied by eruptions, earthquakes, and other signs of the existence of volcanic action, we shall then have obtained an amount of evidence little, if at all, short of actual demonstration.

CHAPTER III.

THE CAUSE OF HURRICANES, AND ABNORMAL ATMOSPHERICAL VICISSITUDES.

In addition to the morbid effects produced in the animal and in the vegetable kingdom, there are other changes, or aberrations, observed in the material world; not only in the interior of that globe on which it is the destiny of man to live, but, also, in the atmosphere by which it is surrounded. These vicissitudes are great heat and drought at one time, and cold or heavy falls of rain at another, with floods and inundations, as, also, violent storms and hurricanes. These aberrations are observed, more particularly, at epidemic periods, as will be shown hereafter; it becomes, therefore, an important question to ascertain the cause of their production; and their relation to the abnormal effects observed in the animal and vegetable kingdom—whether these different phenomena are produced by different causes; or whether they are common effects of a common cause. If the latter, we may be enabled to obtain evidence of the operation of this almost universal cause—that to which epidemics have been ascribed—when other and more direct proof is wanting. Leaving the minor vicissitudes for the moment, we will consider those grand phenomena of nature termed hurricanes, or cyclones—the cause of which is at present an enigma. No attempt even was made, until lately, to analyse these phenomena, or to ascertain the laws by which they are governed. In an able article on this subject, contained in the *Edinburgh Review,* for January, 1839, the writer remarks : "It is mortifying to the pride of science, and a reproach to every civilised government, that we know so little of meteorology—of the laws and perturbations of that aërial fluid, which exists within and around us; which constitutes the pabulum of life; and in which we should instantly perish, were it either polluted or scantily supplied. Considering the earth's atmosphere, merely in its chemical and statical relations, our knowledge of its properties is at once extensive and profound. We have decomposed the gaseous mass into its elements, and ascertained their separate agencies in sustaining and destroying life—its weight, its variable density, its altitude, its action upon light, its electrical and magnetical phenomena, its varying temperature, whether we ascend from the earth, or move to different points on its surface, have all been investigated with an accuracy of result honourable to the industry and genius of philosophers. But, however great be the knowledge which we have acquired of our aërial dominions, when in a state of serenity and peace, we must confess our utter ignorance of them in a state of tumult and excitement. But the last few years, two or three individuals have devoted themselves to the study of the gales and hurricanes that desolate the tropical seas, with a zeal and success which the most sanguine could never have anticipated. They have not, indeed, yet succeeded in discovering *the origin* of these scourges of the ocean; but they have determined their general nature and character; and have thus been able to deduce infallible rules, if not to disarm their fury, at least to withdraw us from their power." Before the attention of philosophers was directed to the investigation of individual tempests and hurricanes, it was generally believed, that a gale differed from a breeze only in the velocity of the air which was put in motion. The first person who opposed himself to this vulgar error was the late Col. Capper, of the East India Company's service. After studying all the circumstances connected with the hurricanes which occurred at Pondicherry, in 1760 and 1773, this intelligent observer inferred, that hurricanes were whirlwinds, whose diameter could not be more than 120 miles. These observations seem to have excited no attention, until Mr. C. Redfield was also led to the subject by independent observations. He concluded, with Col. Capper, that the hurricanes of the West Indies, like those of the East, were great whirlwinds. He found, also, what had been merely hinted at by Col. Capper, that the whole of the revolving mass of atmosphere advanced with a *progressive motion*—the direction on the coast of America being from south-west to north-east.

Mr. Redfield draws, as the result of his investigations, the following conclusions:—(1) The hurricanes of the Atlantic commence to the eastward of the West India Islands. (2) These storms cover, at the same moment of time, an extent of contiguous surface, the diameter of which varies from 100 to 500 miles or more. (3) They act with diminished violence towards the exterior, and with increased violence towards the interior, of the space which they occupy. (4) While in the tropical latitudes, or south of the parallel of 30°, the storms pursue their course towards *the west*, on a track which inclines gradually to the northward, till it approaches the latitude of 30°. In the vicinity of this latitude, their course is changed, somewhat abruptly, to the northward and eastward, and the track continues to incline gradually to the east until they terminate.*

* *Observations on the Hurricanes and Storms of the West Indies, and the Coast of the United States.* 1866.

Mr. Redfield has given the course and the progress of twelve different hurricanes, the principal of which have been marked on the map, at the end of the volume. The hurricanes of the West Indies have also been analysed by Col. Reid, who had ample opportunities for observation during his residence at Barbados. The result of his observations and researches has been given in a work specially devoted to the subject; and it is interesting and important to know, that he has established the same facts, viz., that these hurricanes are progressive; that they pass over nearly the same lines at each visitation; and that they form, during their course—from their commencement, in or near the Windward Islands, to their termination on the north-east coast of America—a sort of parabolic curve. This will be apparent, not only by a glance at Map 2, but also by the following histories, selected from a number related by the preceding writers.

The first we will refer to is the hurricane of September 1804, which swept over the Windward Islands on the 3rd of that month; the Virgin Islands and Porto Rico on the 4th; Turk's Island on the 5th; the Bahamas and Gulf of Florida on the 6th; the coast of Georgia and the Carolinas on the 7th; the great bays of Chesapeake and Delaware, and the contiguous portions of Virginia, Maryland, and New Jersey, on the 8th; and the States of Massachusetts, New Hampshire, and Maine, on the 9th. On the heights of New Hampshire, it produced a violent snow-storm. It appears to have passed from Martinique to Boston, by the usual curvilinear route, in about six days, a distance of more than 2,200 miles—being at the rate of about fifteen and a half miles per hour.

The hurricane of 1827, commencing like the former, at the Windward Islands, on the 17th August, visited St. Martin's and St. Thomas on the 18th; passed the north-east coast of Hayti on the 19th; Turk's Island on the 20th; the Bahamas on the 21st and 22nd; was encountered off the coast of Florida and South Carolina on the 23rd and 24th; off Cape Hatteras on the 25th; off the Delaware on the 26th; off Nantucket on the 27th; and off Table Island and the Porpoise Bank on the 28th. It traversed this course—about 3,000 nautical miles—in eleven days, being at the rate of eleven miles an hour.

Another memorable hurricane—that of 1830—after passing the Windward Islands, visited St. Thomas on the 12th August; was near Turk's Island on the 13th; at the Bahamas on the 14th; on the Gulf and coast of Florida on the 15th; along the coast of Georgia and the Carolinas on the 16th; off Virginia, Maryland, New Jersey, and New York, on the 17th; off George's Bank and Cape Table on the 18th; and over the Porpoise and Newfoundland Banks on the 19th, having occupied about seven days in an ascertained distance of more than 3,000 miles. The progress of this hurricane was about eighteen miles an hour.

These hurricanes, as will be evident by an inspection of the map, do not always commence at the same point, nor do they always traverse the whole of the line, but a portion only, and, sometimes, a very small portion of it. This was the case with the hurricane and *snow-storm*, which swept along the American coast, on the 13th, 14th, and 15th January, 1831, from lat. 30 deg. to lat. 45 deg. N. But whether the course be long or short, these hurricanes invariably pass over the same, or nearly the same lines. There are, however, other hurricanes of this region, which, commencing at about the same points as the preceding, proceed in a nearly westerly direction across the continent of America: as was the case with the hurricanes of June, 1831, and August, 1835, as shown in the map. The cause of the variation will be explained hereafter.

There is another region, no less remarkable for hurricanes, or cyclones,—that of the Mauritius—the phenomena attendant on which have been attentively studied by several scientific observers, and their course accurately defined. As we shall have occasion to refer to the phenomena presented by these hurricanes hereafter, it is not necessary to describe them more particularly at present. Their course has been delineated on Map 1.

Various explanations have been offered of the cause of these grand aberrations of nature. Mr. Redfield, if he has any definite opinion on the subject, would seem to infer, that cyclones are produced, like ordinary gales, by the admixture of different currents of air or of clouds, unequally charged with heat and moisture. Such a cause, which must be local and accidental, will never account for the progression of hurricanes over considerable spaces of the terrestrial sphere, and their limitation to particular lines. Reid has referred them to electro-magnetism, and Professor Hare and other observers to electricity. That electricity is developed to a considerable extent, during the generality of storms and hurricanes, is undoubted; but the quantity present varies greatly on different occasions. Mr. Thom, an army surgeon, who was stationed at the Mauritius for many years, and who devoted much time and attention to an investigation of the hurricanes of that region, states; "It is affirmed at the Mauritius, by many persons, that thunders are never present during the hurricanes, so rare are these phenomena."* Of thirty-two hurricanes, that have occurred at the Mauritius, eleven were accompanied

* *The Nature and Course of Storms in the Indian Ocean, south of the Equator.*

by thunder and lightning: while, in twenty-one, there was no indication of such phenomena. We may therefore regard the electricity, developed on these occasions, as an effect of the same cause as that productive of the other phenomena; not the cause of the latter. This is Kaemtz's opinion, who remarks: "If we examine all the circumstances, that accompany the development of electricity, we must consider the condensation of vapour as the cause of its production; and conclude, that it is the storm which produces the electricity, and not the electric tension which produces the storm, as is the general opinion." And he remarks, in another place: "If we compare all that has been written upon storms, we do not hesitate to conclude, that they are the most complicated phenomena of meteorology. I suspect, that a long time will elapse, before we can account for all the circumstances by which they are accompanied."* Dove concludes, that the hurricanes of the West Indies owe their origin to the intrusion of the upper counter-trade wind into the lower current.† If that were the cause, the path of these hurricanes ought to be along the margin of these winds, and in the opposite direction to their course; but that is not the case, in the majority of these storms, excepting at their point of departure, and for a small portion of their route. This conclusion, like the preceding theories, is mere hypothesis, unsupported by a particle of proof. Other and more vague opinions have been enunciated on the subject, but it is unnecessary to refer to them; it is sufficient to add, that no rational or feasible cause has been, as yet, assigned, for the production of these grand atmospherical phenomena. All that has hitherto been done, is to define the laws by which hurricanes are regulated—an important step, doubtless, in a

* *Meteorology*, pp. 366—7. † *The Law of Storms.*

theoretical as well as in a practical point of view. It will be desirable, therefore, to ascertain, what these laws are. They are as follows.

1st. Hurricanes occur along well-defined lines of the earth's surface; these lines being sometimes rectilinear, sometimes curvilinear. The validity of this law must be evident from what has gone before, and will be rendered still more so by a reference to Maps 1 and 2 in the Appendix.

2ndly. Another law, characteristic of these phenomena, is the regularity of their progress along these lines; their rate of travelling being about the same on each occasion of their occurrence. This, at least, is the law in each hurricane region, but the rate is not always the same in different regions. In the West India hurricanes, the rate, according to Mr. Redfield, is from twelve to thirty or forty miles an hour: in those of the Mauritius, it is not more than from five to twelve, as calculated by Col. Reid and Mr. Thom.

3rdly. The course of cyclones, or great hurricanes, is generally and principally across some portion of the ocean, where their effects are more severe than on dry land. Hence, as Mr. Redfield remarks, the most violent effects on land are usually felt from those storms, that enter and blow from the open ocean, or from the coast. It is also found, when hurricanes pass over islands, that the fury of the storm increases, as it approaches the sea on the opposite side.

4thly. The last law that we shall consider, is the limited duration of hurricanes, both generally and locally, and their periodical return. The *general* duration of a cyclone will vary at different times and in different regions, according to the length of the track pursued by these aërial and destructive agents. The general duration of the West

India hurricanes varies from six to twelve days: in the South Indian Ocean, the duration is longer, extending sometimes to eighteen or twenty days. The *local* duration, in the former region, of the most violent portion of the storm, at the different parts over which it passes, is, according to Mr. Redfield, about twelve hours; but its entire duration, he adds, is, in many places, more than twice that period. As the general duration of the hurricanes in the South Indian Ocean is greater, so also is the local. Mr. Thom states, that the passage of a storm, over the Mauritius, from the time that the barometer begins to fall, until it has regained its usual level, is seldom under seventy-two hours, but the duration of the violent portion of the storm, at a given point, would, of course, be very much less.*

By a reference to the first chapter, it will be seen, that the laws of hurricanes, and the laws which regulate the effects of volcanic action on the surface, are nearly identical. If so, the cause of the one, in all probability, will

* It was my good fortune to encounter a Mauritius hurricane, on board one of the late E. I. Co's. ships, during her voyage from China to England. I say good fortune, for a more magnificent sight cannot well be witnessed by the eye of man, on account of the height of the waves in that wide expanse of sea: they were, not figuratively but literally, mountains high. We were three days preparing for the enemy, having been warned of his approach, not only by the gradually increasing strength of the wind, but, also, by the as gradual fall in the barometer—28 F. being hurricane point in that region. When the storm burst upon us in all its fury, there was nothing but a storm stay-sail set; and we then had to scud under bare poles for twenty-four hours, but the extreme violence of the wind did not last more than twelve hours. It was in one of these hurricanes, that the gallant Admiral Trowbridge perished, his ship and three other men-of-war having foundered: but not one of the Indiamen, they were convoying, was lost. They were laden with tea; and a ship with a tea cargo is more buoyant than any other.

be the cause of the other. A variety of facts would appear to confirm the truth of this conclusion. One is, that hurricanes, or cyclones, are generally observed in particular regions: the principal hurricane regions being the West Indies, the Mauritius, and the China sea. Now it so happens, that all these regions are volcanic, there being an active volcano in the Isle of Bourbon, while eruptions are also recorded to have taken place in the Island of Madagascar. The China sea, also, is bounded by that remarkable chain of volcanos, that extends from Barren Island, in the Bay of Bengal, to the Philippine Islands, and some distance beyond.* As regards the West Indies, it will be seen, by a reference to any geological work, that the district over which the hurricanes of the West Indies usually pass, is evidently volcanic; and, what is still more remarkable, the course pursued by these storms, during the first and principal part of their course, passes over the very tract marked out by geologists as the lines and boundaries of the volcanic action in these regions. "The volcanic islands of the Antilles," observes one writer, "seem to be the links, which connect the chain of primary mountains in the Caraccas with that which runs across the islands of Porto Rico, St. Domingo, Jamaica, and Cuba; while the connection is evidently extended through the whole of the Leeward and Windward islands, which, with the above, form, as is well known, a regular crescent. The connection between these different volcanic islands, is evinced from the earthquakes, to which the non-volcanic chains above mentioned are so subject, ceasing upon the breaking out of an eruption in one of the volcanos of the neighbouring islands." † ‡

It has been before remarked, that some of the West

* See Map 1. † Rees' *Cyclopædia.*

‡ It is probable, that the volcanic Band turns northward, near

India hurricanes, instead of forming a parabolic curve, and turning northwards at lat. 30° N. and long. 75° W., proceed in a direct westerly course to the American coast. This was the case with the hurricane that passed over the islands of Antigua, Nevis, and St. Kitt's, on the afternoon of Aug. 12, 1835; St. Thomas', St. Croix, and Porto Rico, on the 13th; Turk's Island and Hayti, on the 14th; the vicinity of Matanzas and the Havana, on the 15th; was in the Gulf of Mexico, on the 16th; in long. 94° on the 17th; and at Matamoras on the 18th, whence it extended as far as Texas. Another example is afforded by the hurricane of Aug., 1831, which, after desolating the Island of Barbados on the 10th, passed in nearly a direct course to the northern shores of the Gulf of Mexico and New Orleans. It arrived there on the 16th of that month, having traversed, after its departure from Barbados, a distance of 2,300 miles in six days. This route is only what we might have expected some of these hurricanes would take, as the volcanic band of this region evidently branches off, about long. 75°, in two different directions; one towards the north, and the other directly west, until it is lost in the great chain of the Andes. The connection, indeed, of the volcano, in the Island of St. Vincent, with those of South America, has been shown in a previous chapter. When we thus find, that these grand phenomena of nature pass over the lines marked as volcanic, at least in the three principal hurricane regions: that they are confined to those regions; and that they

to Grenada, and then extends along the west coast of Africa, as far as the southern extremity of Europe. My reasons for drawing this conclusion are, that the yellow fever has occasionally extended thus far but no farther. Be this as it may, the volcanic Band does not appear to extend beyond, or as far as, Tobago, as this island, and the settlements to the south, have hitherto been exempt from the hurricanes that afflict the other islands.

obey the same laws as other well known effects of volcanic action, little doubt can exist as to the cause of their production. They must be referred to that subterranean process, which, as it would seem, is productive of so many, and such varied, effects in the material system, as well as in the organic kingdom.

Assuming, for the moment, that this conclusion is a valid one, it remains to ascertain, whether we can, on this hypothesis, account for the different effects observed during the occurrence of hurricanes; and, more particularly, their gyration and progression along well-defined lines of the earth's surface. Mr. Redfield attempts to explain the rotation of storms, and their progression in a particular direction, on the assumption that the winds blow in horizontal circuits round the great oceanic basins. This conclusion will not hold good, for some of the hurricanes of the West Indies, instead of making a bend to the N.W. along the American coast, pass, as already stated, in a straight line, directly across the continent of America. Dove and Piddington consider, that the progression of hurricanes may be referred, like the cause, to electro-magnetism. The latter remarks:—"It appears to me, that a simple, flattened, spiral, stream of electric fluid, generated above in a broad disc, and descending to the surface of the earth, may amply and simply account for the commencement of a cyclone: and that its gradual propagation onwards, in such direction as the laws of the forces generating it, in the upper regions, may give it, will as simply account for its continuance and progression."* Such an explanation is merely adding hypothesis to hypothesis, and leaving the question more complicated than it was before. According to Espy, this movement (that of progression) may depend on an ordinary wind,

* *The Sailor's Horn Book.* 5th Ed., p. 338.

which, imparting a common motion to the whole atmosphere, would not disturb the ascension of the column of moist air."* But as Thom truly observes:—"It would be absurd to suppose, that a primary impulse, given to a discoid body of air, would send it spinning from the coast of Java to the Cape of Good Hope, with a rotatory velocity increasing, to a certain extent, with its forward movement. The primary momentum would be expended, by the friction it would encounter from opposing currents and terrestrial impediments, ere it had moved many degrees." (*Loc. cit.*, p. 161.) Dove also states, that "the idea of the advance being due to impulsion is as unnatural as that of its being due to attraction: for the path of the cyclone (in the West India hurricanes) crosses that of the trade winds at an angle, which is nearly that of a right angle."

With respect to the cause of the "gyration" better and more definite opinions have been enunciated on the subject. Espy concludes, that the whirl, or gyration, is produced by the ascent of a column of warm air, and the rushing in of the surrounding atmosphere to fill up the vacuum. And he adds:—"The cause of the convergence of the currents (of air) to a centre, is the latent heat, which is set free by the condensation of aqueous vapour into a cloud, by means of which the air, in which that vapour had been suspended, is dilated six times as much as it loses in volume by the condensation of the vapour." Hence he infers, that "the circumstances favourable to the sudden production of a tornado are: a warm and humid atmosphere, covering a country sufficiently level and extended." Referring to this theory, Dove remarks:—"The very nature of a *courant ascendant* presupposes the existence of some cause, which imparts a tendency to the

* *The Philosophy of Storms.* London, 1841.

air to rise at one point more than at any other in the neighbourhood: whether the phenomenon be due to heat or to the condensation of aqueous vapour. It seems, however, unjustifiable to suppose, that such a predisposing agency could travel, for days and nights, along a definite path." (*Loc. cit.*, p. 263.) This will be more particularly true with respect to the West India hurricanes, which traverse so many degrees of latitude, and pass from an inter-tropical to an extra-tropical climate. If, therefore, the ascent of a column of warm air be the cause of the gyration, we must seek for some other agent than the climate, or the temperature of the locality, in which these hurricanes prevail.

Although unable to agree with the preceding writers respecting the cause, the phenomenon remains; for the fact, that there is a column, or mass, of air in the centre of the revolving disc, of a different meteorological condition to that of the surrounding atmosphere, is undoubted; and has been demonstrated by a variety of observations. In the 1st place, it has been satisfactorily shown, that there is a dead calm in this central area, or *focus*, as it is usually termed: the calm, like the revolving mass of air, being progressive, and extending from one end of the line to the other. For instance, when a hurricane has been passing over an island, and after the tempest has unfolded its most terrific powers, a perfect calm sometimes supervenes suddenly. After lasting from three or four to six hours, the hurricane will recommence with all its former violence, but at a point of the compass opposite to that where it left off. Again: ships at sea, after encountering the hurricane in all its fury, have suddenly found themselves in the midst of a calm with a clear sky above. In the tremendous hurricane encountered by the "Exmouth," when the mercury was below the level of the scale, the wind became suddenly hushed, and the sun broke forth in the midst of the calm. Colonel Reid also states, that during a hurricane in the North Atlantic, it was remarked by those who were in the centre of the storm, that while all around was one dark mass, it was perfectly clear over their heads. In these instances, the gale, after some time, has usually recommenced with all its former violence—the interval varying according to the position of the vessel within the focus. In the hurricane of 1841, in the Southern Ocean, the duration of the calm, on board the "Windsor," was eight hours: in the "Neptune" storm, six hours; and, with some of the vessels in the "Albion" storm, in 1808, only an hour or two. As such, we may infer, that the centre of the focal area passed across the first-named ships: and only a segment of it over the last. Little doubt, therefore, can exist of there being, in the very centre of the aërial vortex, a column of air in a perfectly quiescent state. That this air is of a higher temperature than that of the surrounding atmosphere, we may infer, not only from analogy but from the fact, that the thermometer has been found to be several degrees higher within than without the focus. In the hurricane of 1840, the thermometer at the Mauritius, which, according to Mr. Thom, was 77° or 78°, for thirty hours before the vortex arrived, rose to 80° soon after, although raining heavily at the time. A confirmation is thus afforded of the hypothesis, that there is a column of warm air at the focus; and that to the existence of this ascending column of air, the gyration is to be referred. But, then, the problem, to what cause the production of this moving column of warm air is to be referred, remains! As no reasonable or sufficient cause above the surface has been as yet assigned for its production, we must glance into the interior of the globe, in order to ascertain if the process there going on be sufficient for the purpose; more particularly as it has been already inferred, that the remote cause of hurricanes is volcanic action. Now it has been shown, in the previous chapters, that one of the effects of volcanic action is the evolution of gaseous matter, not only from the ducts of volcanos, but, also, along particular lines of the earth's surface, and in situations far removed from any active volcano. If, therefore, gaseous matter be given out from volcanic foci, along the lines traversed by hurricanes; and if this matter be of a higher temperature than that of the surrounding atmosphere, an explanation would be at once afforded of the source whence the column of warm air is derived, and, consequently, of the cause of the gyration. What the temperature may be of the gaseous matter, when extricated from the subterranean reservoirs, it is impossible to say; but if it contained, as we may assume, a considerable quantity of vapour, either in a sensible or insensible state, its subsequent condensation would readily account for the increased temperature of the extraneous matter, or moving column, of air. That there is a large quantity of vapour contained in the air within the vortex is undoubted; as it is only on this supposition, that we can account for the heavy fall of rain observed during the prevalence of hurricanes. "Of all the phenomena," says Thom, "developed during rotatory storms, in the Indian Ocean, there is none more constant and remarkable, we may almost say awful, than the enormous quantity of water which is precipitated from the mass of atmosphere in agitation. For hundreds of miles, on every side of the vortex, there is a dense stratified bed of clouds, pouring out rain in torrents, without intermission. This process is continued for weeks, and appears to be a usual characteristic of the hurricane in all its phases, and over every tract of sea or land, which it sweeps." (*Loc. cit.*, p. 186.) The absolute quantity of rain, which falls, at Port Louis, during hurricanes, has been ascertained on one or two occasions to be as follows :—

		In. L.	Barom.
Hurricane of	1786	6.1	28.90
" "	1789	8.4	28.70
" "	1836	8.6	28.23
" "	1840	10.0	28.90

Very nearly equal to one-fifth of the whole amount which falls over the island during the year.* As it is impossible to account for the presence of so large a quantity of vapour within the focal disc, by causes above the surface, we are necessarily led, independently of all previous arguments and conclusions, to look beneath the surface for the production of this effect. Although a large quantity of aqueous vapour is given out from volcanic foci, during eruptions and earthquakes, it is probable, when the path of the hurricane is across the ocean, that the vapour is derived from this source, as the gaseous matter would, if of a higher temperature, imbibe a certain portion on its passage through the water.

Not only are we thus enabled to account for the existence of the column of warm air, in the centre of a whirlwind, on the above hypothesis; but we shall also be enabled to understand, what would otherwise be an anomaly—the great extent of the calm within such a vortex. The width of the aërial band, or cylinder, varies from 100 to 500 miles, and that of the central calm at from 20 to 30 miles, and has been thus calculated. At Port Louis, in the Mauritius, the calm, in one of the hur-

* It has been calculated, by Sir John Leslie, that, if all the aqueous vapour contained at one time in the atmosphere, at the point of saturation, was to be let fall at once, it would not exceed five inches in depth.

ricanes mentioned by Thom, commenced *four hours* before it reached Touillac, at the opposite end of the island—twenty-six miles; and as its appearance, at the last place, was almost simultaneous with its cessation at the former, it may be inferred, that its diameter was nearly equal to this distance, and its progression about five miles an hour. Now it seems difficult to understand, why this wide expanse of air should not be involved, or, at least, to a great extent, in the general whirl, merely because its temperature is above that of the surrounding space. There must be some lateral, as well as upward pressure, some *vis a tergo*; otherwise this internal, as well as the external, mass of air would soon become involved in the vortical action. If, however, the internal column of air be derived from subterranean reservoirs, it must be expelled with some force, sufficient, we may presume, to prevent its being drawn into the surrounding whirl. As, also, the gaseous matter would be extricated along the whole of the path pursued by the hurricane, we can understand, why this central calm should continue from the commencement to the termination, or near the termination, of the course. It also appears, that the diameter of the focal area varies according to its position on the path traversed, being greatest at the commencement of the line, smallest at the termination. "Facts, as well as hypothesis," remarks Mr. Thom, "indicate the calm, in the centre of a rotatory gale, to be very much more extensive at the beginning." The diameter at that time, according to the above observer, is, in the Indian Ocean, about eighty miles. At the other extremity of the course the calm is scarcely perceptible. This is precisely the result we should expect, if the column of air, or gaseous matter, be derived from reservoirs beneath the surface; and if it be extricated along the whole of the hurricane line. We can also explain, on the same hypothesis, why the most severe hurricanes are experienced on the ocean ; it having been before stated, that all active volcanos are near to the sea, or in communication with it ; thus showing, that eruptions are due to the precipitation of water on the melted lava, and the sudden generation of a large quantity of steam. We may also conclude, that the extrication of gaseous matter would also be favoured by the same circumstance. Hence its greater evolution along these pathless tracts of the ocean. As, also, this matter is extricated beneath the bed of the sea; and as it must pass through the waters of the mighty deep, the hydrostatic pressure exerted on the surface of the earth, in these situations, would prevent its escape, unless it exerted a force sufficiently great to overcome this pressure. To do this, it must be in a state of great compression—equal to the pressure of many atmospheres—so that when it did escape, it would be with more violence, with greater rapidity, and in greater quantity than in other situations. These conclusions granted, we can understand why these hurricanes are only met with, in their severest form, in particular regions, as, also, why these regions should be oceanic.

The question has arisen, whether the gyration is caused by a centripetal or a centrifugal force. Mr. Espy, who advocates the former opinion, remarks : "During hurricanes, the wind, instead of blowing in a circle, rushes directly from the exterior towards the centre, under the influence of the suction power, caused by the rarefaction and ascent of air in the centre of the revolving mass." To this it has been objected, that a very few minutes, if such were the case, would suffice to cause a cessation of the process, by restoring the loss of equilibrium between the different portions of the cyclonic mass, and the circumjacent atmosphere. Nothing, it is argued, but the centrifugal effects of circular motion, extending to a great elevation, are capable of presenting sufficient resistance to the lateral pressure of the surrounding masses; so as to preserve a cylindrical body of air in a state of isolation for a period of several days, with a diminution of weight equal to one or two inches of the barometer—a fall constantly observed in the focus, or centre, of the cyclone. Mr. Taylor infers, that if the air rises from any point, and the air about that point flows in from all sides towards it, the result will be to produce, not as Espy and Hare assert, a direct centripetal confluence, but a whirlwind in the sense of the cyclone theory.* In proof of this, it may be mentioned, that the wind blows with the greatest violence at the margin of the central area, or region of calm. Although these conclusions are, no doubt, valid, there is one circumstance which appears to show, that the centripetal force has some influence in the production of the whirl. In the Southern Ocean, the gyration of the air, in the whirlwind, is in the direction of the hands of a watch, or, S. W. N. E.: but in the Northern, or West Indian Ocean, the gyration is in the opposite direction, or S. E. N. W. Now the course of the hurricanes, in the former region, is along the margin of the S.E. trade wind, which, by impinging on the column of air, would tend to turn it in the direction indicated. As, also, the N.E. trade, or monsoon, does not extend as far south as the hurricane track, there would be no opposing force to turn the revolving disc in the contrary direction. On the other hand, the course of the West India hurricanes is along the margin of the N.E. trade—at least from their commencement until they turn northwards, at about lon. 75°. This wind, therefore, when it impinged on the storm disc, would have a tendency to make it revolve in the opposite

* Herschel's *Meteorology*, p. 67.

direction, more especially as the revolving mass would be separated from the S.E. trade wind by the belt of equatorial calms. As there would appear to be no other way by which we can explain the variation of the gyration in the two hemispheres, the probability is that both causes—a centri fugal and a centripetal—are in operation during a cyclone. This is Mr. Thom's opinion, who remarks: "In the first stage of a circular storm, it is probable, that the wind blows round the exterior with greater violence than towards the central space, which would appear to be occupied by air almost in a state of stagnation. But as the external motion is imparted to the interior portion of the mass, and *centrifugal* action begins to withdraw the air from the centre, and from the up current, the whole will soon be involved in the same vortical action." Instead, however, of the centripetal action commencing first, I should myself infer, that the centrifugal action commences first, the centripetal last; and for this reason,—the evolution of gaseous matter, along a particular line of the earth's surface, would of itself tend to produce a whirl. This, however, is immaterial: it is sufficient, at the present moment and for the present object, to have ascertained the cause of the gyration of hurricanes: that of their progression is sufficiently explained by what has gone before: it is due to the evolution of gaseous matter along the line traversed by hurricanes.

Such are the arguments which have been employed, in order to show, that hurricanes are produced by the extrication of gaseous matter from volcanic foci; and that the cause exists beneath not above the surface. It may be, and, doubtless, will be said, if all these effects be produced by volcanic action, we ought to have other and more direct evidence of the existence of this process at the moment. The argument is a sound one; although it is impossible to obtain the same amount of evidence in these cases as in some others, and for this reason—the course of these hurricanes is generally across the ocean, where the effects arising from volcanic action are less apparent than on dry land. Still, there are indications and proofs of the existence of this process, at particular times, during the occurrence of hurricanes; independently of the fact, that the principal hurricane regions are all volcanic. One of these indications is the appearance of a peculiar and singular cloud. Thus, in the Barbados hurricane of 1831, Mr. Simons, of St. Vincent, observed, *before the storm reached that island,* a cloud to the north of him, so threatening in its aspect, that, as he informed Colonel Reid, he had never seen anything so alarming, during a residence of forty years in the tropics. It was of an olive green colour. Mr. Simons hastened home, and, by nailing up his doors and windows, saved his house from the general calamity. The same phenomenon has not only been observed at other times, but it is usually considered to be the harbinger of an earthquake, in those countries where the latter occurrence is frequent. Dr. Stukely states, it has been generally remarked, in the history of earthquakes, that they begin in calm weather with a black cloud.* Again: the earthquake which occurred at Naples, in 1730, was accompanied by an atmosphere overcharged with *dense, low, immoveable clouds,* which shortly afterwards disappeared. A second phenomenon, characteristic of volcanic agency, and of the escape of gaseous matter from volcanic foci, is the darkness so generally observed during these severe hurricanes. In the graphic account of a typhoon in the China sea, encountered by the Idaho, an American frigate, the captain says: "The darkness was intense, and the mistiness of the air, laden with spray,

* *Phil. Trans.* Vol. 10, p. 110, and 7, p. 46.

was so great, that, at times, the mainmast was invisible from the quarter deck."* The same effect was experienced in the severe hurricane, that visited the West India Islands in 1867; the Wye, an inter-colonial steamer, having in consequence, although it was mid-day, run ashore on Buck Island and foundered, with the loss of sixty-five souls. The almost total darkness, it is stated, that prevailed, was the cause of many other accidents.

Another indication of the operation of subterranean forces, at these periods, is the sea-wave which so frequently occurs. This was particularly marked in the hurricane just referred to, on account of the disastrous results that ensued. The Rhone, one of the West India Packets—a magnificent 14-knot steamer of 3,000 tons burden—was lying at Salt Island at the time, in consequence of the prevalence of yellow fever at St. Thomas. According to the account of an officer of the Conway, that had just left the Rhone, after transferring passengers and cargo, a fearful hurricane was blowing at 11 a.m. from N.N.W. half W. At 12.15 p.m. the wind had lulled, and at 12.30 p.m. had become almost calm, but the darkness was intense. The Rhone was then seen steaming to seaward, but, shortly after, a most fearful rush of wind from S.S.E. half E. set in; the sea rose suddenly, lifted the Rhone as though she had been a top or a cork, threw her on shore, and broke her in two. With the exception of three, all the passengers (130 in number, and who were lashed on deck), all the officers of the ship, and about half the crew, were swallowed up in the foaming abyss.† Col. Reid concludes, that the wave, or "the accumulated water of

* *Standard*, Dec. 23, 1869.

† There was, in the *Illustrated London News*, a striking representation of this scene, with the Rhone riding on the crest of this immense wave.

the sea, is raised by the power of the wind"; but no such effect could be produced by such a cause in the narrow and confined sea between some of the West India Islands. Besides, these waves are too sudden, and of too limited an extent, in the generality of cases, to allow us to draw such an inference: the wave that destroyed the Rhone not having been felt at Santa Cruz, only 26 miles distant. These effects cannot be accounted for, without referring them to the operation of some cause beneath the surface. We have, in fact, proof, that similar phenomena are the direct effect of volcanic action, as they sometimes occur simultaneously with eruptions and earthquakes. At Concepcion, a volcano broke out beneath the sea, at the very time that a great sea-wave rolled in on the shore. In 365, in the reign of Valentinian, a fearful earthquake was experienced throughout the whole of the Roman Empire; a sea-wave being produced at the same time, in the Mediterranean, so tremendous, that ships were carried over the tops of the highest houses for two miles inland. At Alexandria, 50,000 persons were drowned.* In the Lisbon earthquake of 1755, "the bar, at the mouth of the Tagus, was seen dry from shore to shore; then suddenly the sea, like a mountain, came rolling in, and, about Bellem Castle, the water rose 50ft. almost in an instant."† "At Funchal, in the island of Madeira, the sea, which was quite *calm*, was observed to retire suddenly some paces; then, rising with a great swell, without the least noise, and as suddenly advancing, it overflowed the shore, and entered the city."‡ On the northern side of the island, the wave was still greater. In the hurricanes of 1780, two of the most tremendous visitations of physical

* Gibbon. *Rise and Decline of the Roman Empire.*

† *Hist. and Philos. of Earthquakes*, p. 316.

‡ *Phil. Trans.*, Vol. 49, p. 432.

power, which have been let loose upon the globe, concussions were experienced. In the first of these instances, after the tempest had abated, the sea, as we are told, exhibited an awful scene; the waves swelled to an amazing height, rushed with indescribable impetuosity on the land, and overwhelmed the town of Savannah La Mar. When the waters began to abate, *a most severe shock of an earthquake was experienced.* In the second, called the great hurricane, and which followed in about three weeks, Sir George Rodney stated, that nothing but an earthquake could have occasioned the foundations of the strongest buildings to be rent; and he therefore concluded, that the violence of the wind prevented the inhabitants from feeling *the earthquake, which,* he was assured, *attended the storm.* As a confirmation of these conclusions, it may be remarked, that all the great earthquakes in Jamaica seem, by the accounts that have been given of them, to have come from the sea, or from the east, and then to have gone northwards—precisely the course taken by the hurricanes. So, also, in the last hurricane, in the West Indies, that of 1867, concussions were distinctly felt, and it was supposed, at first, that the island of Tortola had been submerged. On the 18th Nov. also,—a month after the hurricane—a severe earthquake was felt in the same island, and even beyond. At Santa Cruz, it was accompanied by a sea-wave, which lifted an American man-of-war lying there at anchor, and *landed her in the market place.* Another serious concussion was felt at St. Thomas' on the 2nd of Dec.; the sea rose 40ft.; many lives were lost, and much property was destroyed. Subsequently to this, the island of St. Bartholomew was almost entirely destroyed by a volcanic eruption; while concussions of the earth were occurring, almost every day, at Porto Rico. It is not necessary, however, to depend on indirect evidence, we have direct proof, that whirlwinds are sometimes the effect of volcanic agency. At the commencement of the eruption of Tombaro, a volcano in the island of Sumboya, fire and columns of flame continued to be given out, until the darkness, caused by the falling matter, obscured the mountain, at about 8 p.m. An hour afterwards, a violent *whirlwind* ensued, which blew down nearly every house in the village of Saugor: and tearing up, by the roots, the largest trees carried them into the air, together with men, horses, cattle, and whatever else came in its way. The sea rose twelve feet higher than it had ever done before, sweeping away houses, and everything within its reach. "No explosions," adds Sir S. Raffles, "were heard *until the whirlwind had ceased* about 11 p.m." The same result was observed after the earthquake in Nicomedia, which, according to Macellenus (Lib. xvii. c. 71), was accompanied by a hurricane. Lastly: during the occurrence of an earthquake in Seville, in 1504, a tempest arose, so violent that, according to the writers of the day, the end of the world appeared to have arrived.* Minor effects of the same kind are common in the neighbourhood of active volcanos: hence they have been termed, by Humboldt, volcanic storms. Little doubt therefore, can exist as to the connexion between hurricanes, and the process that is going on constantly beneath our feet.

In addition to the preceding, evidence can be obtained from the opposite series of phenomena; the same as was shown to be the case, while considering the cause of epidemic diseases. This is the fact, that hurricanes are rare, and almost unknown, in the region of extinct or nearly extinct volcanos. In the geographical distribution of thunder storms, remarks Humboldt, the Peruvian coast, where *thunder and lightning are unknown*, presents the

* *Anales de Sevilla.*

most striking contrast to the rest of the torrid zone, in which, at certain seasons of the year, storms take place daily. Dr. Bryson also states, that the regions, immediately contiguous to the great chain of the Andes—the volcanos in which are now nearly extinct—are not swept by the typhoon, or the tornado. It is, also, precisely in these regions, that epidemic diseases, as previously shown, are unknown. No less worthy of remark is it, that hurricanes are rare, if not unknown now, in the Mediterranean ; yet they formerly prevailed there to a great extent. It would also appear, that they were cyclones, judging from the description given by Virgil of one of them. He remarks :—

> " *South, east, and west,* with mixed confusion roar;
> And roll the foaming billows to the shore." *

These circumstances would lead us to infer, that hurricanes, like diseases, are produced during a particular period of the volcanic process, at the commencement rather than at the termination of it. We have thus indirect as well as direct evidence, in proof of the proposition before laid down, viz., that hurricanes are the effect of volcanic action.

If, however, we infer, that hurricanes, or cyclones, are the effect of volcanic action, we must also conclude that minor effects, which exhibit the same characteristics, are also produced by the same cause. This is more particularly the case with that singular and interesting phenomenon, the water-spout; which traverses certain lines of the earth's surface, and exhibits nearly the same phenomena as hurricanes. According to Professor Osted, the water-spout is a strongly agitated mass of air, which passes over the surface of the earth, and revolves on an axis, of which one extremity is

* The *Æneid,* 1, *l.* 126.

on the earth or in the sea, and the other in a cloud."* The uppermost portion is generally wider above than below, having the form of an inverted cone, or funnel—the middle portion being narrow, and sometimes twisted.† The lower portion is, apparently, wider than the upper, but, probably, only apparently so, owing to the quantity of water or of earth, when the water-spout passes over the land, which is hurled round the column by the vortex. The diameter of a water-spout varies from 100 to 1,000 feet. That of the narrow portion has been estimated at only a few feet. A height of from 1,500 to 2,000 feet has been assigned to most water-spouts, but some have been seen at such distances, that the height could not have been less than from 5,000 to 6,000 feet. That they revolve on an axis has been clearly shown. Mr. Walker, Master-Attendant at H.M. Dockyard, Plymouth, stated to Colonel Reid, that he sailed through a water-spout in the Bay of Naples, and that its rotation was with the hands of a watch. The water-spout is, in fact, a progressive column of air, or gas, combined with vapour, which, becoming condensed by contact with the surrounding air, falls in the form of rain, or water, all around. As the course of these erratic bodies is usually very short, there is no time for the production of a hurricane, which would otherwise be observed. They may therefore be regarded as abortive hurricanes. The occurrence of water-spouts is particularly interesting, as they enable us to observe, as it were in miniature, the phenomena that occur in the centre of a hurricane. That they are produced by the extrication of gaseous matter from beneath the surface, may be inferred, not only from analogy, but from the following circumstance. Peltier states, that the sea at the commencement, or before the appearance, of the water-spout, often exhibits

* Jameson's *Edinburgh Journal*, July, 1839. † See Sketch in Map 1.

a remarkable agitation (*bouillonement*) like that of boiling water.*

The validity of the preceding conclusion will be better shown, perhaps, by referring to a similar phenomenon observed on land: and when, instead of water, sand is alone present. These sand-spouts, or whirlwinds of the desert, as they are termed, are common in Arabia, and in the sandy plains of the northern part of Africa. According to Rich, "they are generally seen to commence by rising *out of the earth* with violence: like a burst of smoke from a volcano, and gradually extending themselves upwards:" † to a height of from 500 to 700 feet. They then begin to whirl, increasing in diameter as well as in height until they attain the size of a large tower, which marches on majestically across the plain, along a well-defined line. One is immediately followed by another, until, at last, 20 or 30 of these columns are seen apparently chasing each other across the desert, drawing up and whirling round the sand, over which they pass. Hence their designation. Here then we have precisely the same phenomena as in the hurricane, excepting the presence of vapour and the fall of rain. This circumstance lends countenance to the opinion before expressed, that the large quantity of vapour present in the air, in the hurricanes of the West Indies and of the Southern Ocean, is derived from the waters of the deep. We may also infer, that the whirl, in this instance at least, is pro-

* A prettier sight, at sea, cannot be met with than one of these apparent columns of water, walking majestically over the bosom of the ocean and throwing up, all around, large quantities of spray —the effect of the falling water. It is desirable, however, to keep at a respectful distance, as small vessels and boats, that have crossed the path of these sea-cataracts, have occasionally been sunk by the deluges of water thrown on the deck.

† *Babylon and Persepolis*, p. 228.

duced by a centrifugal, not a centripetal force. In order to show the connection between these phenomena and hurricanes still further, it may be remarked, water-spouts and sand whirlwinds are sometimes stationary for a time. It is the same, occasionally, with hurricanes, as in that of the Albions, in the South Indian Ocean; and, also, in the Bahama hurricane, in 1838.*

These are not the only aberrations that are observed, in that aërial fluid which surrounds our globe; and in which we are destined to live and breathe, and have our being. There are others, which, although not presenting the same grand and striking phenomena, are yet, perhaps, productive of more injurious results to man than even storms and hurricanes. These are, as previously remarked, great heat and drought at one time, or the reverse, severe cold, and heavy falls of rain, with floods and inundations, at another; in situations and at seasons, when such phenomena are abnormal or unusual. These aberrations have occurred, of late years, to such an extent, that it becomes a question of no small importance to ascertain, what the real cause is—whether temporary and accidental, or a regular and permanent one.

The question that we have to consider, therefore, is, can these aberrations be explained by a reference to well-known meteorological laws and theories, or must we look to some other cause for an explanation of the phenomena? The latter would appear to be the only answer to the question. Take, for instance, the great heat and excessive drought experienced at particular times, and in particular localities; while places situated in the same parallel of latitude, or only removed a few degrees from them, are suffering from cold or rain. In the year 1816, when the middle of Europe was deluged with excessive rains, the

* See Col. Reid's Work, p. 433.

north, to a certain extent, was parched with drought; and public prayers appear to have been ordered, about the same time, at Dantzic and Riga for rain, and at Paris for sunshine. In other instances, severe cold will be felt in one locality, or country, while mild weather is experienced in another; although the climate and temperature of both are nearly the same under ordinary circumstances. Sometimes, a severe winter will be felt in temperate climates, and a mild one in northern latitudes; while at other times, heavy and continued rains will be experienced in what should be the dry season, and the reverse, or dry weather, in the rainy season. These are anomalies, that do not admit of explanation by reference to any known meteorological theory, although that proposed by Dr. Hutton does account for certain anomalies, that are sometimes observed in the formation and descent of rain. As to the *immediate* cause of the production of rain, this can only be ascribed to the condensation of the vapour, which constantly exists, to a greater or less extent, in the atmosphere; it being a law of nature, now absolutely demonstrated, that water has a tendency to assume the elastic form, *at all temperatures,* however low. There is not a particle of air, either in the torrid zone or in the frozen regions of the north, free from its given proportion of aqueous vapour. As, also, the vapour, thus diffused in the atmosphere, is derived from the waters, that cover so large a portion of the globe, this evaporation is constantly going on, to a greater or less extent, in all situations and in all climates; not only at the equator, but at the pole. Such being the case, we might suppose, that an undue accumulation of moisture would take place in the atmosphere, on the one hand; or that the store would, on the other, become exhausted in time. "But, as this evaporation is due entirely to the active agency of heat, nature has fixed limits, beyond which it cannot pass; for as the temperature on the surface of the earth, whatever may be its capricious changes, is confined in every climate within definite bounds; so, the minimum temperature of any period, whether it be that of a day, a month, or a year, must set a limit to the accession of watery vapour in the air; and thus, in every region—the equatorial, the temperate, and the polar—a strong and impassable barrier has been fixed by nature to the continued accumulation of moisture in the air. As, also, this heat is retained within certain limits, and is differently distributed on the surface of the earth, it follows, that the rising moisture is compelled to distribute itself throughout the different regions of the great aërial volume according to well-known and fixed laws; for as there is a gradation of heat from the equator to the poles, so a given volume of air will contain less and less moisture, as we leave the equator and approach the poles."*

If these deductions be correct, it is clear, that not only will a certain quantity of vapour be present in the atmosphere at all times, but, also, that the proportion contained in a given quantity of air will vary in different regions—being greatest in the equatorial, and least in the polar regions. When, therefore, a condensation of the atmospheric vapour occurs, either in consequence of the accidental withdrawal of the sun's rays, or from the natural changes in the seasons, so as to cause its descent on the surface of the earth, we should expect to find, that the greatest quantity which fell would be near the equator, and the least near the pole. That this is the case, in general, there can be no doubt; for, as the preceding writer justly observes, amidst the seeming diversities, which characterize the descent of rain, and which

* *Enc. Metr.* Art. Meteorology.

impress, on particular localities, qualities which seem to set all investigations at nought, we may yet conclude, that the maximum descent of rain will be found in the equatorial regions; and, at the same time, a diminution in its quantity from those regions to the poles. If, therefore, this rule were found to be invariably the case, and if the fall of rain in all climates was only observed on the supervention of cold weather, or after a sudden diminution of temperature in the surrounding atmosphere, the theory as to the formation of rain would be simple enough; for the evaporation produced by the heats of summer, and the condensation caused by the cold of winter, and the vicissitudes in the temperature, which occur at all periods, would account for the phenomenon. But there are certain anomalies of a very marked character, which present themselves to our notice, and which cannot be explained by a reference to the above causes alone. Some, however, have been accounted for in two different ways.

In the first place, it has been proved, that the evaporation on the surface of the globe is not the same in every latitude, or where the temperature is equal. Thus, the Mediterranean Sea, surrounded on all sides by land, is more heated than the ocean; while the winds, which blow over it, being drier, there is a more copious evaporation than in the Atlantic itself. This increased evaporation must therefore produce, at a subsequent period, and in a certain portion of the globe, a greater condensation and fall of rain than what is witnessed in other situations in the same parallel. Again: with the same average temperature throughout all the months of the year, the different currents in the air will at once introduce diversities of a very considerable kind. Thus, the annual evaporation at Whydah has been estimated at 64 inches; but, when the harmattan blows, the rate is augmented to 133 inches.

This circumstance therefore would cause subsequently, in that locality, a greater fall of rain than what is observed in other situations, where the annual temperature is the same. In the next place, it has been found, as before remarked, that rain frequently falls, either in quantities greater than can be accounted for by the previous evaporation from the surface, or, else, at unusual periods of the year; and when, from the temperature, we might infer, that evaporation not condensation would be produced. To meet this, and certain other anomalies, Dr. Hutton proposed a theory, which differed from those of preceding writers. According to this philosopher, rain results from the mingling together of great beds of air of unequal temperatures, and unequally stored with moisture—a conclusion that has since been adopted by Leslie, Dalton, and other distinguished writers. In this way, we are able to account for the production of rain in situations and at times, when no elucidation is afforded by a diminution in the general temperature existing above the surface: as the only conditions necessary for the formation of rain, according to the above theory, are the accidental contact of certain portions of air differently charged with moisture, and of unequal temperatures; conditions which must constantly exist, to a greater or less extent, over the whole globe, and during all seasons; for neither caloric nor vapour can be immediately, and, at once, equally and uniformly diffused through the whole of the atmosphere. One portion of air, therefore, which contains a given quantity of caloric and moisture, will, when brought into contact with another portion, differently charged, cause precipitation; or, in other words, a fall of rain. By this theory, we are not only enabled to account for the occasional showers, which are experienced in all climates, independently of the periodical fall of rain at particular seasons, but we can also explain certain anomalies, which are observed in particular situations and at particular times.

In the first place, the great atmospheric currents, produced by the trade winds, cause periodical descents of rain, which differ from those in other regions. The sea and land breezes, also, in tropical climates, by the blending together of opposite currents, produce, either daily or at particular seasons, the phenomenon of rain. As, also, the heat of the sun, which produces a greater abundance of rain in certain regions, situated near to the sea, or large masses of water, becomes the cause of drought in situations farther removed from the sources, whence the moisture is supplied; so, on the other hand, there is sometimes an absence of all precipitation, even when currents of air, differently charged with caloric and moisture, are mingled together. Thus, there are certain situations where it seldom or never rains; as in the sahara of Africa, the low coasts of Egypt, and a portion of the coast of Peru. But, then, a particular wind prevails in these situations; and, as a wind constantly uniform, or nearly so, must, according to the theory of Dr. Hutton, either produce constant precipitation or none at all, it follows, that the permanency of the cause, in these situations, insures the permanency of the result. As it is the south-west wind which prevails constantly at Peru; and, as it passes from a colder into a warmer region, its capacity for moisture becomes increased, and hence there is no precipitation. We may also add, that dry weather is usually accompanied by a steady and uniform direction of the wind in most climates, at the same time that the winds are unsteady and variable in rainy weather. But these aberrations, although exceptions to the general rule, as regards the diffusion of vapour in the atmosphere, and its subsequent condensation and fall, are yet, it will be observed, to a certain extent, uniform in their result—being either felt constantly in particular situations; or else their occurrence, when experienced, can be ascribed to certain fixed principles.

But there are other changes and vicissitudes, which cannot be explained by a reference to the above theory, more than to any other; for the aberrations are so great, that it is impossible to refer their production, either to increased evaporation on the one hand, or, on the other, to a sudden and unusual mixture of different strata of the atmosphere—the temperature not being sensibly increased; while the fall of rain frequently occurs in the midst of very calm and settled weather. From a series of observations that were made on the Malabar coast, from 1810 to 1823, we find that there was a deviation of more than 75 inches of rain, between the result of two years; at a time, when the difference of the mean temperature of the same years did not amount to a single degree. Again, the mean annual amount of rain on the Malabar coast is, it has been calculated, about 123 inches; while, in England, it only amounts to 31 inches; and, at St. Petersburgh, to 16. But this proportion is frequently reversed; so that we have a greater fall of rain in a high northern latitude than what is observed in countries near the equator. Many instances have been adduced of excessive rains, for the parallels on which they fall; but the most extraordinary are those, which occurred on the continent of Europe, in 1827, and which are recorded in the 36th volume of the *Annales de Chemie*. Independently of places, where rain, less in amount, was noted to have fallen in unusual quantities, it was found that, at Joyeuse, on the 9th of October, 1827, there descended, in the space of 22 hours only, the enormous amount of 31 inches—

being as much as what is usually observed in the same parallel during the whole year. The greatest diurnal amount, that had been observed in this place, during a period of 23 years, was 9 inches; and even this was considered at the time a very large quantity. In other situations, instead of the above aberrations, or an excessive fall for a short period, or during some particular year, we find, that there is a gradual increase for a long series of years, at the same time that the climate, or temperature, and all other external circumstances remain, apparently, as before. It has been satisfactorily ascertained, that the quantity of rain, which falls annually at Paris, has not varied in any sensible degree for 130 years; but it appears, from the result of a series of observations made at Milan, that the rain has been constantly augmenting from 1764 to 1816—the period during which the observations were made.

Now these are anomalies, which can never be explained by any theory hitherto proposed; although that of Dr. Hutton's does account, not only for the general formation and descent of rain over the whole globe, but also for certain other anomalies, or exceptions, to the general rule. Such being the case, we are not only bound to conclude, that the above theory, when applied to the general formation and descent of rain, is a correct one; but, also, that the cause of the changes and vicissitudes, now referred to, must be different from that usually concerned in the formation and distribution of rain over the general surface of the globe. Still less can we explain those abnormal accessions of heat, or of cold, before referred to, by any cause existing above the surface, unless it could be shown, that these particular localities are exposed to the rays of the sun, while others are screened. As no such result as this has been witnessed, our only resource is to look to the earth beneath, rather than to the heavens above, for an elucidation of the phenomena. In so doing, we shall find that atmospherical changes and vicissitudes constantly occur in well known volcanic regions, both before, at the time, and subsequently to, the eruption of the volcano, and the shock of the earthquake. These are irregularities in the seasons; sudden gusts of wind, interrupted by dead calms; violent rains in countries, or at seasons, when such phenomena are unusual or unknown; a reddening of the sun's disk, and a haziness in the air, often continued for months; an evolution of electric matter or inflammable gas from the soil, with sulphurous and mephitic vapours, etc. These effects are not confined to the immediate neighbourhood of the volcano, or to the places where concussions are felt: they are sometimes observed over extensive areas of the earth's sphere. This is more especially true with respect to great heat or drought. Webster remarks: "An evidence of the effects of fire, or electricity,* on the earth and air, before its explosion, is *the extreme drought* which is so often experienced over whole continents, or the whole world, for 6, and even 12 months, *antecedent to a great eruption of volcanos.*" Many instances, adds this writer, have been related: it is sufficient here to mention *the excessive drought* in 1762 and 1782, *preceding eruptions* of Ætna and Hecla. In these years, almost all springs were exhausted, *not only on the continent of Europe*, but, also, over *a great portion of America.*

While, on the one hand, volcanic eruptions and earthquakes are generally preceded by heat and drought, so, on the other, they are usually accompanied or followed by heavy rains, with floods and inundations. This effect, in

* As may be remembered, this writer attributes eruptions and earthquakes to the action of electricity.

the immediate neighbourhood of the volcano, must be ascribed to the immense volumes of aqueous vapour generally evolved from a crater during eruptions; and its condensation in the surrounding atmosphere. At times, the quantity of vapour evolved is so great, that torrents of water roll down the sides of the mountain, producing more havoc and destruction to the surrounding inhabitants than the lava. Torre del Greco was destroyed in this way, during the memorable eruption of Vesuvius in 1794. It is, also, generally concluded now, that the destruction of Pompeii and Herculaneum was caused by a torrent of water and mud rather than by a shower of ashes: the effect was too sudden to be produced by the latter alone, while other circumstances confirm this conclusion. In these instances, it is probable, that the water or a portion of it is derived from beneath not above, being extricated, like the lava, from volcanic foci. Not so with the heavy falls of rain, the cause of which must be entirely atmospherical, especially as we observe the same result after earthquakes. Deluges of rain followed an earthquake, which laid a part of Antioch in ruins, A.D. 458; the shocks of which were felt throughout Thrace, the Hellespont, and Greece. Whole cities in Bithynia were swept away by the torrents.* A fact which seems indubitable, says Humboldt, "is the mysterious influence, in equinoctial America, of earthquakes on the climate, and on the order of the dry and rainy seasons. In these regions where, sometimes, for ten months together, not a drop of rain falls, repeated earthquake shocks, which do no injury to the low reed huts of the natives, are regarded by them as the welcome harbingers of abundant rain, and a fruitful season." (*Loc. cit.* p. 201.) The Baron also states, that the atmosphere seemed to dissolve itself into water, immediately after the

* *Byzantine Hist.* b. 15.

earthquake which destroyed the city of Cumana ; and while the ground was in a state of continual oscillation. We are also informed by Sir Willm. Hamilton, that after the earthquake which visited Italy, in 1783, "the part of Calabria, which suffered most from the earthquake, was drenched with long-continued and heavy rain ; with frequent and furious squalls of wind." So apparent, indeed, is the connexion, at particular periods, and under particular circumstances, between atmospherical phenomena and terrestrial concussions ; and so generally is the one set accompanied by the other, that, as previously stated, the changes in the electrical states of the atmosphere were long supposed to be the cause of the concussions. Even now, there are writers who contend, that earthquakes are produced from this cause or from electricity. But, as Mitchell truly remarked, long since, it is more probable that the air should be influenced by the earthquakes, than that the earth should be affected in so extraordinary a manner, and to so great a depth, by a cause residing in the air.* If such be the result in volcanic districts, we cannot err greatly in concluding, that the same effects are produced by the same cause, in other situations ; in those, in which the phenomena are inexplicable by a reference to any well-established meteorological theory ; although there may be no evidence, at the moment, of the existence of volcanic action in that particular locality. That this conclusion is a valid one, may be inferred for the following reasons. If we peruse the accounts, that have been transmitted to us, of these excessive or unusual falls of

* Alluding to this subject, Humboldt asks : "Do gaseous fluids issue from the interior of the earth, and mingle with the atmosphere ? Or are these meteorological processes the effect of a disturbance of the electricity of the atmosphere by the earthquake ?" (p. 201.)

rain, we shall find, that there is the same order, or progressiveness, in their appearance, as with other and well-known effects of volcanic action. Thus, periods of great rain have usually been preceded by droughts, or hot and dry seasons; the same as takes place in volcanic districts at the time of the eruption of volcanos. In addition to the above, it will be seen that the rain, in these instances, is confined either to particular localities, or to well-defined lines of the terrestrial sphere: for while rain is frequently found to extend a considerable distance, the width of its range is very limited, so that we are able, in numerous instances, to trace the boundaries of considerable falls of rain, as well as the limits of particular and slighter showers. Now it would seem difficult to imagine, how any cause, existing above the surface, could be thus limited in its operation; especially if we refer the variation in these instances to a change of temperature in the atmosphere; for the operation of such an agent would be more general. Besides, there is frequently no perceptible variation in the temperature of the atmosphere, at these particular periods; at the same time that unusual winds and currents of air are entirely wanting. If, also, we find, that other signs of volcanic action have been observed in these localities, either before or subsequently, every doubt on the subject would appear to be removed. All, therefore, that we have to do now, is to inquire into the manner in which the effects under consideration are produced. If due to volcanic agency, there is only one way in which we shall be able to account for their production. This is by inferring that gaseous matter is extricated, at such times, into the surrounding atmosphere, either alone, or combined with aqueous vapour—the same as has been concluded is the case during hurricanes, the only difference being that there is in general no wind. This difference, in all probability, may be referred to the greater facility with which gaseous matter escapes from the ducts of volcanos: it having been before concluded that hurricanes are produced by the sudden escape of gaseous matter, while in a state of great compression. Be this as it may, the evolution of gaseous matter, even uncombined with aqueous vapour, if it be of a higher temperature than the surrounding atmosphere, is alone sufficient to account for the heavy falls of rain; as the intermingling of different bodies of air, differently charged with heat and moisture, if occurring to a sufficient extent, would be productive of the effects under consideration. Hence it is, that fires produce rain; a fact well known to the Indians, who, according to Espy, set fire to the grass, when they wish for a fall of rain. For the same reason, clouds form over manufacturing cities to a greater extent than over other towns.

With respect to the floods and inundations, that are so generally the accompaniment of these particular falls of rain, they may arise from two different circumstances. They are sometimes produced directly, by the quantity of rain that falls: but this cause is insufficient, in other instances, to account for the phenomena,—the quantity of water distributed over the surface being too great to be derived from such a source only. If not from above, the water must come from beneath the surface—an inference we should be induced to draw, irrespective of the previous arguments and conclusions, from the fact, that floods and inundations frequently occur during the eruption of the volcano and the shock of the earthquake. In addition to the discharge of water from the duct of a volcano, there is, also, an apparent escape of water, from the interior, by other channels. Thus, during the eruption of volcanos, and, more especially, at the time of the occurrence of earthquakes, new springs are seen to burst forth; the water of old ones often becomes muddy, and their contents overflow, or are discharged with violence, and in considerable quantity. Independently of this effect, the water in the neighbouring rivers or lakes is found to rise suddenly above its level, and to overflow its natural boundaries—an effect which is, doubtless, produced by the great and sudden discharge of the contents of those springs which, we know, abound more plentifully beneath the waters of the ocean, rivers, and lakes, than on the dry land. This effect may sometimes be produced by the formation of a rent, or fissure, as was the case in the earthquake at Oporto; when the river, we are told, opened, and disclosed a chasm, from which immense quantities of water were spouted up. But the same phenomena, or the rise of the water in lakes and rivers, and the overflow of springs, are frequently observed in situations far removed from the spot, where the concussion is felt; so that we are assured they are produced by the discharge of water through natural channels, not accidental chasms. That, during the shock of the earthquake, the water of springs, far removed from the centre of the concussion, is frequently affected in an extraordinary degree, has been already mentioned in a preceding chapter, while detailing the phenomena witnessed in different countries during an earthquake at Lisbon. In addition to the examples then given, it may be mentioned, that, even as far as Bohemia, the mineral springs, which supply the warm baths, suddenly rose, and filled the baths in the course of a few minutes. At the same time, the water in the different ponds, canals, and springs, was agitated and overflowed in England and other countries, near the seat of the concussion. The immediate cause of the phenomenon is, probably, this. We have seen, that during the eruption of the volcano, an immense quantity of aqueous vapour is given out from the crater; the effect, as we may presume, of the precipitation of water on the melted matter in volcanic reservoirs. If, therefore, we allow, as we are bound to do, that these reservoirs extend over considerable portions of the terrestrial sphere, and in situations far removed from any active volcano, we have only to suppose, that steam is generated beneath the surface, in those particular localities, as well as near the focus of the concussion, in order to account for the production of the above phenomena, even in districts not known to be volcanic; for if neither rents nor chasms have been formed on the surface, the inference is, that the elastic vapour would endeavour to escape by those natural outlets, which exist, to a greater or less extent, over the whole globe, and from which both gaseous and solid matter is so constantly given out from the bowels of the earth. If these deductions be correct, we may not only understand why floods and inundations are experienced at times, when it is impossible to account for their production by any unusual or excessive fall of rain; but, also, why they are observed in situations, where no sign of volcanic action is in existence at the time.

This is not all. There are other phenomena, closely allied to irregular falls of rain, that would appear to prove, still more clearly, the connexion that exists between atmospherical vicissitudes, and the process that is constantly going on beneath our feet. The phenomena here alluded to are those fearful scourges of the agriculturist —hail storms. By a reference to the facts which have been recorded by different writers, we shall find, that the effects of such storms, although felt over considerable tracts, have their lateral boundaries very narrow, and so defined, that it is easy to ascertain the extent of their range. Another phenomenon is no less remarkable and important, as regards the present inquiry; this is, the regular progression of hail storms along well-defined lines of the earth's surface. That such is the case, may be gathered from the tremendous storm, which desolated so great a portion of France in July 1788. "It began in the south, close to the Pyrenees, and proceeded in two parallel bands from the south-west to the north-east; the extent of one of them being 175 leagues, and of the other 200: thus traversing nearly the whole length of that kingdom, a portion of the low countries, and extending as far as the Baltic. The mean breadth of the eastern band was four leagues, and of the western, two; and, what is very remarkable, the interval between the two bands, amounting to five leagues, was deluged with heavy rain. Its progress from south to north was at the rate of 16 leagues an hour; and the continuance of the hail at each place, or town, was limited to 7 or 8 minutes."* Another example of the definite extent of hail storms has been recorded by Mr. Neill, in the *Transactions of the Royal Society of Edinburgh*. In the storm which occurred in Orkney, on the 24th of July, 1818, a thick layer of hail, says this gentleman, formed a tolerably well-defined belt across the island, in a direction from south or south-west to north-north-east. "It was about a mile broad, and so limited was its range, that persons engaged in digging turf, two miles to the westward of what appeared to be the very centre of the storm, were wholly exempted from its effects." Independently of the above, we find that hail storms are peculiar to certain situations, so that particular localities have been designated as hail countries; while no assignable cause, as difference of climate, or temperature, can be

* As will be evident from the facts adduced in the first chapter, the path of this hail storm is precisely that pursued by the epidemic diseases of the last pestilential epoch.

given for this peculiarity. It would therefore seem, that we must look to local, not general, causes for the production of hail storms. That the effects, now referred to, do not proceed from any *general cause* existing in the atmosphere, as decrease of temperature, or an undue accumulation of aqueous vapour in the upper and colder regions, and its condensation there, seems proved by the fact, that the clouds from which hail descends are generally situated very low. Thus, M. Arago mentions, that he has more than once seen clouds, from which hail, a few minutes later, escaped abundantly, cover, as with a thick veil, the whole extent of a valley; whilst the neighbouring hills enjoyed, at the very time, a pure sky and an agreeable temperature. Von Buch also remarks, that it very rarely hails on mountains in the temperate climates of the earth; and this he attributed to the low elevation of the clouds, from which hail descends. Hence it has been inferred, that hail is caused by the descent of rain, through a stratum of cold air,—a conclusion apparently confirmed by the fact, that hail frequently precedes storms of rain, and sometimes accompanies them, as we have already seen. It is probable, therefore, that they have a common origin; and that the difference observed is merely an effect of the difference of temperature in that part of the atmosphere, where they are formed—the same as we observe rain at one season of the year, and snow and hail at another.

As regards the explanation now given of the formation of hail, two difficulties, it has been argued, present themselves, viz., whence the great cold, which causes the water to freeze, is derived; and next, how the hail stones, after having once become large enough to fall by their own weight, can yet remain suspended in the air long enough to increase to such sizes—hail stones having sometimes weighed 12 or 13 ounces. These anomalies have always excited the attention of philosophers: among others, of Volta, who regarded the formation of small flakes of ice —the kernels of future hail stones—in the month of July, and during the hottest hours of the day, as one of the greatest paradoxes in meteorology. And so it will continue, as long as meteorologists confine their attention to the atmosphere above, regardless of the earth beneath, for a solution of the paradox. And yet, it is not necessary to look very far. We have already seen, that these storms, —like the still greater phenomena, hurricanes,—obey the same laws as volcanic action: while the fact, that the hail is formed in the lower strata of the atmosphere, ought alone to convince us, that the cause is beneath not above the surface. That the process, which is constantly going on in the interior of the globe, is sufficient for the purpose, we have proof from the phenomena, which are sometimes witnessed in volcanic districts. Thus, we frequently hear of hail and falls of snow after the eruption of volcanos, even in the hottest countries or during the middle of summer in colder climates. In the eruption of Hecla, Iceland, in 1783, fire burst from the earth, at a distance from the volcano: snow, hail, and extreme cold, being generated in the *immediate neighbourhood of the flame!* Ice has, also, been met with, in the craters of Hecla, of Vesuvius, and of Ætna. It is unnecessary to attempt to prove, on the present occasion, that the effects, in these instances, are to be ascribed to the same cause as that which produces the discharge of melted matter, for the connexion between these different phenomena is too apparent to admit of any doubt.

That snow and hail should be produced by the agency of fire, or volcanic action, appears somewhat paradoxical upon a first consideration of the question; but it will cease to be so, if we conclude, that hail is caused the same as rain, by the mixing together of atmospherical strata, of different temperatures and unequally charged with aqueous vapour. All we have to do, in this case, is to ascertain, whence the warm stratum of air is derived. This must be, according to the preceding arguments and conclusions, from subterranean reservoirs. The phenomenon may, however, be explained in another way.

As is well known, heat is produced by the condensation of gases; cold, by their rarefaction, and hence the cold in mountainous regions.* A more apt illustration is afforded by the condensation and vaporisation of carbonic acid gas. When this gas is condensed in a strong iron cylinder to a sufficient extent—with a pressure of 30 atmospheres—it becomes fluid. After the condensation, if the stop-cock, with which the cylinder is provided, be turned, *snow* is immediately formed around the mouth of the pipe, and it continues to form as long as the gas escapes. The reason is obvious. So large a quantity of caloric is absorbed by the conversion of the fluid into a gaseous form—an inevitable result when the pressure is removed—that the temperature of the air surrounding the gas, is reduced below the freezing point; the consequence is, that the aqueous vapour is at once converted into ice, or snow, and falls to the ground. With this result before our eyes, we have an easy and sufficient explanation of the phenomenon under consideration. If, at those great depths to which volcanic reservoirs penetrate, certain gases exist—as we have a right to infer—in a state of great condensation; we have only to conclude, that these gases escape, under particular circumstances, from the interior to the exterior, in order to account for the production of snow and hail in

* The air, at the summit of the Alps, is so chilled by *rarefaction* that the clouds of vapour become snow, which accumulates, and descending slowly into the valleys forms the wondrous ice-rivers, termed glaciers!

certain localities, and along certain lines of the earth's surface. As, in the previous experiment, the flakes of snow are only formed in the immediate neighbourhood of the tap; so, also, it would only be along the volcanic lines, and in the lower strata of the atmosphere, that the hail would be formed. Hence the cause of the formation of hail, and the limitation of its range.

As regards the other anomaly, the long suspension of the ice-kernels, there are some observations of Mr. Martin, in the *Philosophical Magazine*, which appear to offer a solution of the problem. This gentleman says, that "there is only one way in which he supposes such masses of ice, as are sometimes formed, can be suspended long enough in the air to grow to such enormous sizes, and that is by the assistance of a nebular whirlwind; with sufficient power to keep them in its whirl, and to resist the earth's attraction, whilst the concretive action is going on; till their momentum overcomes the suspending power, or till they are thrown beyond the range of its intensity." This inference is, no doubt, a correct one, for hurricanes, as we have seen, are only progressive whirlwinds; and if hail storms are produced by the same cause, we should expect to find that they would exhibit the same phenomenon. Independently of the above, Mr. Martin states, that he once saw, during a hail storm, a narrow column of dark vapour, which he could distinctly observe to be in *rapid rotary motion*, and passing from one cloud to another. The result is more apparent in the following instance, in which the hail was combined with a regular whirlwind, or tornado. The *Globe* states, the steamer Adriatic, which arrived at Queenstown yesterday (June 3, 1873), brings details of a terrific whirlwind, accompanied by *hail* and rain, which passed over Washington, Iowa, on the 22nd May. "Its path," the despatch states, "was about half a mile in width, and it tore to fragments everything in its course—houses, barns, fences, trees, and human beings were caught up, whisked through the air like toys, and then dashed to the ground with such violence as to produce instant destruction. Houses and barns were torn into fragments and scattered in all directions, and, for miles around, the fields are dotted with large timbers driven into the ground at an angle of 10 degrees. The cattle were actually driven headforemost into the ground. One can scarcely conceive the devastation or realize the force of the tornado. Already we have heard of thirteen farmhouses, and many barns, that were literally torn to pieces or otherwise badly damaged. A schoolhouse was totally destroyed, and a daughter of Henry Rothnel, aged 14 years, was carried about a quarter of a mile from the school. When found she was quite dead. . . . A gentleman, who was near the tornado, reports that it was balloon shaped, with the small ends to the ground, and moved at the rate of twenty miles an hour." If, therefore, we allow, that hail storms are whirlwinds, the last anomaly belonging to this phenomenon of nature will disappear, while the cause of its production will be no longer a problem.

These are not the only aberrations that have to be considered; there is the abnormal production of cold, at particular times, and under particular circumstances, and for which no explanation has yet been afforded. When, however, we come to examine the accounts transmitted to us of these aberrations, we shall find, that they, in general, obey the same laws as the other phenomena that have been considered. Thus, extreme degrees of cold are frequently found to be confined to particular lines of the earth's surface; a result that is better observed when there is a heavy fall of snow. Another phenomenon, or law, is the progression of cold at a regular rate, along these lines. A striking illustration of these results has been recently afforded; and is too interesting to be passed over. The meteorogical observations, now made and telegraphed daily in America, disclosed, in February, 1872, the path of a great atmospheric *wave of cold* across that continent. The *Chicago Tribune* states, "on the night of the 11th, the telegram to that city announced that, at Fort Benton, the thermometer had suddenly fallen to 15 deg. below zero, but none of the other signal stations exhibited any marked change of temperature. On the 12th, the thermometer fell 35 deg. at Omaha. At Chicago, it stood at about 43 deg. until midnight, with a very light movement of the atmosphere; the icy wind then arrived, and the mercury dropped 33 deg. in ten hours, and fell still lower in the evening, the wave passing on towards the south-east. It traversed the distance from Fort Benton to Chicago at the rate of 25 to 30 miles per hour; and, it is stated, extended at least 100 miles north of the line from Fort Benton to Omaha, but not so far to the south. The barometer rose as rapidly as the thermometer fell." This singular phenomenon, the progressiveness of cold, is sometimes found to extend over whole continents. Thus, the extreme winter in America, in 1641-2, was one year later than in Europe. And Webster adds: "Several instances have occurred, at other periods, which seem to indicate a kind of *progressiveness*, in great cold, from east to west." As these unusual aberrations of cold thus appear to obey the same laws as volcanic action: and as, in addition to the formation of ice and snow in the craters of volcanos, severe and unusual cold is frequently experienced in the immediate neighbourhood after an eruption; there can be no difficulty in accounting for the production of the same effect, in all situations in which the volcanic process is in operation. We may also explain, in the same way, the heavy falls of snow, and the severe and abnormal winters experienced at particular times and in particular localities, and which are inexplicable on any other hypothesis.

It follows, as the result of the preceding arguments and conclusions, that hurricanes, storms, and abnormal atmospherical vicissitudes, are effects of the same cause as that which produces disease and death in the animal kingdom. This granted, we can understand, why these phenomena are so common, and so constantly observed, at all epidemic periods; as, also, why they are so invariably accompanied by other well-known effects of volcanic action, such as eruptions and earthquakes. By a reference to the historical *résumé* contained in the next chapter, it will be found that pestilence, storms and hurricanes, abnormal atmospherical vicissitudes, earthquakes and volcanic eruptions, not only prevail at the same time, but appear to be inseparably connected together. More than this, the intensity of the one set of phenomena will be found to bear an exact ratio with that of the other phenomena. It is impossible, therefore, to draw any other conclusion than this—that they are all products of one and the self-same cause. Referring to this subject, Van Hoff remarks: "The opinion, whether any relation, or casual connexion, exists between the various movements of the earth, and those occurring in the atmosphere, has for a long time remained unanswered. . . . There can be no doubt, that an answer to the question, whether a connexion exists between these phenomena of fixed terrestrial bodies, and the condition of the atmosphere, is of the greatest importance to a thorough knowledge of the whole."*

* *Geschichte Erdober.* Th. iv.

CHAPTER IV.

EPIDEMIOGRAPHY: OR HISTORY OF EPIDEMIC DISEASES; WITH THE ABERRATIONS IN THE MATERIAL WORLD.

"HISTORY," says Hecker—"that mirror of human life in all its bearings—offers, even for general pestilences, an inexhaustible though scarcely explored mine of facts: here too it asserts its dignity, as the philosophy of reality delighting in truth. . . . But this part of medical history, which has such a manifold and powerful influence over the history of the world, is yet in its infancy." * To give a complete history of the pestilences, that have been observed in the animal and in the vegetable kingdom; of the atmospherical vicissitudes and of the cosmical perturbations that have occurred, during historical periods; would not only require a separate volume, but the labour of a lifetime. If it took Gibbon twenty years to collect the materials for his work, it would take a still longer time to complete a history like the present. The reason is obvious. The materials for the one could be obtained with time and labour: those for the other are scanty and imperfect—historians being more occupied with political events, and the destruction of the human race by wars and civil strife, than by pestilence, famine, and physical perturbations. And yet, while the sword has slain its thousands, pestilence and famine have slain their tens,

* Preface to the *Black Death of the 14th Century.*

their hundreds, of thousands. But so it is: we must take facts as we find them, and man as he is, with his mental obliquity, his follies, and his thoughtlessness. Not having either the time or the inclination to devote myself exclusively to a subject, that is only a collateral one, all that can be done, on the present occasion, is to give a brief *résumé*—a mere catalogue in fact—of some of the phenomena that have been observed, during historical periods, in two regions of the earth—in that previously devastated by the plague, and in that now scourged by the epidemic cholera.

It is usually considered, that the former epidemic, or pestilential, period in Europe commenced with the Black Death of the 14th century: it being then that Hecker dates the origin of this disease in China. This visitation, doubtless, was the longest, if not the most severe on record, but it was not the first: a similar one occurred in the 6th century, the disease, its origin, course and progress, being precisely the same as in the former instance. The epidemic in the first visitation, the same as in the last, was the plague: the description given of it by the Arabian physicians removes all doubt on this subject. More than this, we may also infer, that some of the pestilences which afflicted Egypt, Asia Minor, and Europe, before and after the commencement of the Christian era, were identical with it. Be this as it may, we have proof that pestilence, murrain, and blight in corn, prevailed in these regions from the most remote period. That disease and death would prevail to a great extent, in all the countries situated within, or near to, the volcanic band of the Mediterranean, we should have inferred, *à priori;* and simply as a consequence of the deductions previously drawn. It could not have been otherwise, if pestilences are the effect of subterranean causes, for this region has been one great theatre of volcanic action during all historical periods. As also this region extends from the north of China to the continent of N. America, embracing, on the one side, nearly all the countries of Europe, and, on the other, the northern part of Africa, it is precisely within this area, that we should expect to meet with the effects arising from such a cause. Such, as we shall find, is the fact.

Curiously enough, and contrary to what might have been expected, some of the earliest records of pestilence would be in Ireland, if the chronology of the Irish Annals were correct. Thus, it is stated, that A.M. 2820, or B.C. 2340, all Parthalon's people—a colony from Greece — 9,000 in number, died in one week of *tamh* (plague). This occurred 269 years after their arrival in Ireland; and the tumuli (*Tamhbacht* or plague monument) of these early victims of plague are still to be seen on a plain near Dublin.* There was another pestilence thirty years later, during Neimhidth's reign, who was carried off with 3,000 of his people.† After this, Ireland, according to the Annalists, was a wilderness for 200 years. Between this date and the Christian era, fifteen more pestilences have been recorded, but the nature of them is not known. All we know is, that they were very fatal. This cannot be ascribed entirely to the want of medical aid, as it is mentioned, that Dian-

* These dates are, of course, entirely apocryphal, the facts recorded reposing only on tradition; according to which Parthalon arrived in Ireland 278 years after the flood ! !—ages before the existence of the Greek nation. If, however, they were really colonists from Greece, it is probable, that they arrived there 700 or 800 years before the Christian era. But it is impossible to ascertain the exact date, as Tighernach, the Irish Annalist, states, that the ancient historical documents, existing in his time, were uncertain before the reign of Cunbaeth, B.C. 305.—*Annals of the Four Masters.*

† *Annals of the Four Masters.* Dr. O'Donnovan's Translation.

cecht, the doctor, died of *tamh* A.M. 3303. Nor can these plagues be referred to the want of sanitary arrangements, as they were regular epidemics, and only appeared at particular periods, and sometimes at long intervals. Thus, it is stated that, in the reign of Slanoll (all health) the kingdom was free from all manner of sickness. He reigned twenty-six years.* During another pestilence in 3656, or 353 years later, *three*-fourths of the men of Ireland (of the Milesian race) died of plague.

During this period, only one epizootic has been recorded: this was in the reign of the monarch Breasal, surnamed Bobhiobhadth (cow destruction, or mortality). It is stated, in the *Annals of Clonmacnoise*, that, "In his (Breasal's) time, there was such a morren (murrain) of cows in the land, as there were no more then left alive, but one bull and one heifer, in the whole kingdom, which bull and heifer lived in a place called Gleann-Samasge." This is said to have occurred A.M. 5001, or B.C. 159.†

Turning to the East, the first account of pestilence to be met with there, is that which occurred in Pharaoh's time, B.C. 1487, when the plague of blotches and blains fell upon man and beast. Homer has informed us that a pestilence, which commenced with the brute creation, attacked the Greeks during the Trojan War, B.C. 1190. We also find, that pestilence broke out in Crete, soon after the return of the Greeks from the Trojan War. A century later, the Philistines were afflicted with a plague

* For these, and the majority of other, facts relating to Ireland, I am indebted to the valuable Report of the Census Commissioners for Ireland, 1851, and to the Table of Deaths contained therein.

† The Irish Annalists have adopted the long chronology of the Septuagint, and have made the age of the world before the Advent of Christ, 5160 years.

in Palestine; and it prevailed in the whole of Greece and Asia Minor B.C. 1060, as, also, in Judæa, B.C. 1040, in the reign of David; when 70,000 persons were cut off. Pestilence occurred about the same time in Spain, being the first mention of the prevalence of disease in that country. What was called the Assyrian plague, decimated the army of Sennacherib B.C. 728; while Rome was visited, shortly after its foundation, or B.C. 738, with a pestilence that killed instantly, without any warning. Plutarch states, that the cattle were affected at the same time.* Another plague ravaged Rome, and the surrounding country, B.C. 707, in the reign of Numa; and again in 655, in the reign of Tullus Hostilius. A plague also broke out in Jerusalem B.C. 600, while Nebuchadnezzar besieged the city; and among the Greeks, while laying siege to Cirrha. An immense number of men, women (particularly those with child), and infants, were carried off in Rome B.C. 515, in the reign of Tarquin the Superb; and again in 503 B.C., being accompanied, this time, by a famine. The plague returned again in 490 and 470 B.C., when it was particularly fatal to women. The army of Xerxes, after the battle of Salamis B.C. 480, suffered severely from a pestilence, as well as from famine—the highways being strewed with dead bodies.

In 461 B.C. a pestilence, which, commencing in Egypt, was general over all the Roman Empire, is stated, by Mariana, to have prevailed at the same time in Spain.† Dionysius of Helicarnassus says, it affected equally men and cattle, and he adds: "It seized studs of mares, herds of oxen, and flocks of goats and sheep." According to Livy, a second pestilence, accompanied by a murrain, which destroyed nearly half the cattle, and which was followed by a famine, prevailed in Rome B.C. 459. Nearly

* *Life of Romulus.* † *Historia Generale de España.*

all the slaves, and half the citizens, were carried off, the remainder being exhausted with continual burials—"*urbs assidius exhausta funeribus.*" Another pestilence, that continued for five years, and which affected the cattle, at the same time, broke out in Rome B.C. 437. The celebrated plague of Athens occurred B.C. 430; and Thucydides states, that the cattle and sheep were attacked, as also dogs. Birds flew away, and beasts of prey would not leave their haunts—being sick or dead in all probability. It was said to have commenced in that part of Ethiopia, which borders on Egypt, and then to have extended into Persia, Lybia, and Greece. Papon states, that twenty-two outbreaks of plague have been recorded as having occurred in different parts of the world previously to this. It had ravaged Rome, and the surrounding country, eleven times or more, during the 320 years that this town had then existed.*

Pestilence sprang up again in Italy, in 428, after a severe drought, in 412, 404, 396, 392 and 387 B.C. According to Florian Ocampo, pestilence, accompanied by a severe drought, and followed by famine, prevailed in Spain B.C. 383. So fatal a pestilence prevailed in Rome B.C. 366, that 10,000 are said to have perished in a single day. It was during the prevalence of this plague, that M. Curtius, in the vain hope of arresting its progress, and for the presumed salvation of Rome, threw himself into a chasm, that had been suddenly formed by an earthquake. The plague of this year almost depopulated Carthage. It preceded the outbreak in Rome, as was usually the case; but its appearance in the latter city could not be referred to infection. "The Romans," as Noah Webster remarks, "were not a commercial people, nor had they any commercial intercourse with Egypt till the conquest of Car-

* *De la Peste*, p. 55.

thage two and a half centuries after this period. It was not till 147 years after the time now under consideration, that the Romans owned a single ship." (Vol. i. p. 56.) Another pestilence broke out in Rome B.C. 332, and continued for some years. It affected principally pregnant women and cows in calf; and to such an extent, that it was feared the population and the cattle would become extinct.* A plague, which broke out in Rome B.C. 311, was ascribed, at first, says P. Diaconus, to the corrupt state of the air, until it was *discovered*, that the Roman women had *poisoned* their husbands. This suspicion, we may presume, arose from the circumstance, that the male sex was chiefly attacked; thus affording another example of the fact, that epidemic diseases frequently attack by classes; as was the case in the previous pestilence, when women were the principal victims. The same result is stated to have occurred in 277 B.C., the disease being particularly fatal to breeding cattle, as well as pregnant women.

In 214 B.C. a pestilence broke out in the immediate neighbourhood of Carthagena in the spring, accompanied by a partial famine. It soon extended to other provinces and parts of Spain, cutting off the majority of the principal inhabitants. Hamilca, wife of Hannibal, and their infant, Haspar, with most of their relations and friends, perished at the same time.† In the following year, during the siege of Syracuse, nearly the whole Carthagenian army perished, with their generals—Hippocrates and Himilco—from the combined effect of heat and pestilence; the latter prevailing at the same time in Rome.‡ In 180 B.C. a murrain broke out in Italy, and was succeeded the following year by a pestilence in man. The mortality,

* *P. Orosii Hist. Lib.* iv. p. 2. † *Florian Ocampo. La Chronica Général de España.* ‡ *Epist.* 60.

says Livy, was so great, that the dead bodies lay unburied; carnivorous animals would not touch them, and vultures deserted the place. But one of the most severe pestilences, that had been then recorded, occurred in 126 B.C. According to the preceding writer, 800,000 perished in Numidia alone; 200,000 on the coast of Carthage and Utica, with 30,000 of the Roman troops. No less than 1,500 dead bodies were carried out of one of the gates of Utica in a single day. There must have been another visitation in 74 B.C., as nearly the whole army of Mithridates then perished, together with 120,000 of the inhabitants of Pontus; although, as frequently occurs, it was attributed to poison. A few years later, or B.C. 60, leprosy made its appearance, it is supposed for the first time, in Italy and in Spain. According to Papon, the plague appeared at Marseilles in 49 B.C., while Rome was again nearly depopulated in 30 B.C. Alonso, of Freylas, says it extended to Spain.

As will, probably, have been remarked, there is no account of any pestilence having occurred in England up to this time, or, during the Pre-Christian era. Only one has been mentioned; and this, according to Short, occurred about 470 B.C. This must be ascribed, not to the absence of disease, but to the want of records; for if, as we have seen, so many visitations were experienced in Ireland, there would necessarily have been as many in the sister isle, being placed, as we shall presently find, in the same morbific area. This inference is confirmed by Horace, who, in the 21st Ode, Book 1, says, that Apollo "drives war, famine, and pestilence, from the Roman people, and the Emperor (Octavius Augustus) to the Persians and the Britons." As these Odes were written subsequently to the year B.C. 30, we may conclude, that the pestilence which raged that year in Rome passed on subsequently to Great Britain, like all the pestilences of this period.

Having thus given a brief account of the principal pestilences, in the animal kingdom, that have been recorded previously to the commencement of the Christian era, it will be desirable to ascertain, whether the vegetable kingdom was affected at the same time, as, also, what were the atmospherical and cosmical phenomena then observed.

From the silence of authors on the subject, the principal clue we have to the existence of disease among vegetables, is the occurrence of famine. But then it is impossible, in general, to ascertain whether the famine arose from disease and blight in corn: from destruction of the cattle, or from atmospherical causes—such as drought or the reverse, rains and floods. The first mention of disease in the vegetable kingdom, is in the Book of Exodus, the flax and the barley having been smitten, or blighted, during the abode of the Israelites in Egypt. The next account is by Plutarch, who, in his life of Romulus, remarks, that during the pestilence which occurred in Rome, in 738 B.C., "even *trees* and cattle were not exempt." But the principal famines, recorded at this period, occurred after severe drought. The first mentioned was in Palestine in the time of Abraham. The long-continued famine in Egypt, nearly two centuries later, or B.C. 1708, is matter of history. A severe drought in Spain B.C. 1100, which lasted twenty-five years, and which was accompanied by pestilence and famine, nearly depopulated this country. It was probably at this time that the severe drought in Ireland, said to have lasted ten years, and which occurred in the reign of Eochy Mac Eirck, A.M. 3295 to 3305, according to the Irish Annalists, was experienced. But the first famine, recorded in these annals, is in 4019 A.M., or B.C. 1141. Making every allowance for errors as to date, it is yet certain, that precisely the same phenomena were observed in Ireland, at this period, as in other countries, bordering on the Mediterranean. In this region, or in Italy, B.C. 428, there was a severe drought followed by famine; multitudes of cattle thronged round the arid fountains, and perished with thirst. Thucydides states, that a severe drought and famine followed the plague of Athens, B.C. 426: effects that were observed, at the same time, in Spain. According to Marian, the flocks and herds died from the effects of thirst as well as from disease. Florian Ocampo states, that a severe drought, accompanied by a pestilence, and followed by famine, was experienced in Spain B.C. 383.* On the other hand, there are references to severe droughts without being accompanied by famine: thus leading to the inference, that the famines, in a great many instances, were the result of disease in corn and other vegetables, rather than of the want of rain. Hence no mention is made of famine in Ireland, during the ten years' drought before alluded to; on the contrary, it is stated, that there was abundance of fruit and grain. A severe drought occurred in Italy in 438 B.C., and was followed by a pestilence: and in 393 B.C. the heat was so great, that the soldiers in the army of Brunnus, at that time besieging Rome, perished in such numbers, that the survivors, weary with burying the bodies, burnt them on piles.† In consequence of the heat and the drought in Spain, in 237 B.C. there was a general failure of the crops. The same effect was experienced in 213 B.C. nearly the whole Carthagenian army, with their generals—Hippocrates and Himilco—having perished at the siege of Syracuse, from the excessive heat, as well as from pestilence. As connected with great heat, it may be mentioned, that B.C. 126 a swarm of locusts, said to have come from Numidia, devastated Italy

* *Hist. Hispaniæ, Lib.* 2, *cap.* 6.
† *Encyclopædia.* Art. Chronology.

and other countries bordering on the Mediterranean.* Severe drought and excessive heat were not the only effects then experienced. The reverse, or excessive cold, with heavy falls of snow, were no less prevalent. The year 272 B.C. was memorable in Italy for the severity of the winter. At Rome, snow of a prodigious depth lay on the ground in the Forum for forty days! It is also recorded, that, in A.M. 3942, Finnaghta, who then reigned in Ireland, was so called from the abundance of snow that fell; and in the reign of his son Finnachta (of the wine-snow) snow fell having the taste and appearance of wine.† We hear little of the prevalence of heavy falls of rain, floods, and inundations at this period; either in consequence of their effects being less disastrous, or, possibly, because they did not prevail to the same extent. Inundations of the sea took place in Achaia B.C. 1752; while, what has been termed, Deucalion's Flood, by which nearly all the inhabitants of Thessaly were drowned, occurred B.C. 1558. Ten centuries later, Locris, in the Gulf of Corinth, was submerged in the same way, or by a sea-wave. Floods in Italy, from heavy rains, and the overflow of the Tiber, were experienced a few years after this. Great and heavy falls of rain are, also, recorded as having occurred in Italy, in the years B.C. 54, 51, 45 and 46. Other phenomena were likewise observed at the same period. Pliny mentions the pale colour of the sun in 44 B.C., and states, that it lasted a whole year. This phenomenon has been frequently observed since at epidemic periods, and, also, previous to volcanic eruptions—an effect that may be ascribed to the presence of an extraneous vapour in the atmosphere.

* Webster remarks: the common opinion in Arabia is, that these insects are generated by heat and drought, and destroyed by cold and rain.

† This phenomenon, due to the presence of minute organisms, or fungi, in the atmosphere, was frequently observed afterwards.

As respects the cosmical phenomena in this region—the Mediterranean—there are, remarks Mr. Mallett, a few scattered facts, for the years 1700 to 1400 B.C.; then, from 1400 to 900 B.C.—nearly 500 years—a perfect blank: followed, with a few exceptions, by another blank, from 800 to 600 B.C.* We have records of one in Palestine B.C. 880, and, again, in 870; in China, in 595; in Lacedemon, in 550 and 530; in the Island of Delos, in 486—stated to have been the first felt there; in Sparta, in 469; and, in 462, a violent earthquake rent Loiris, on the Gulf of Corinth, from the mainland, and turned it into an island. The town itself was destroyed subsequently by another concussion. Italy was again shaken in 459, and in 439 B.C. The concussions, in the latter year, being so general and so tremendous, that, to quote the language of Paulus Diaconus, Rome was tired of the numerous messengers —*assiduis Roma nuntiis satageretur*—who arrived with the news of towns and villages demolished. Thucydides states, that earthquakes, which, in 437 B.C., affected the largest part of the (known) world, and which produced the most disastrous results, were followed by an eruption of Etna. There was a concussion in Italy B.C. 426; in Greece, in 425, attended by great inundations; in Lisbon, in 377; in the Peloponnesus, in 373—Heliki being destroyed by an inundation; in Rome, B.C. 364—at which time the *lacus Curtius* was formed in the Forum; in Lemnos, in 323; in Japan, in 284—during which time a lake was formed, 72 miles long and 17 wide; while a volcano, still active, burst out in Delphi, in 283, and was followed by a violent storm of hail, in the Hellespont. It was at this time that the City of Lysimachus was destroyed by an earthquake, which was felt at Cadiz. In 282 B.C. there was a concussion in Campania; in 224, in Rhodes, when the famous Colossus was thrown down; in central Italy, in 221, many cities being destroyed, and rivers turned from their course: while the shocks were repeated 57 times in the course of the year. In Libya, 100 towns were destroyed by concussions about the same period. In 197 B.C., shocks, which lasted for 38 days, were felt in Asia Minor, Rhodes, and Italy; in China, in 173, and 140; followed, in 125, by a severe eruption of Etna. Concussions occurred in Syria, and the Island of Cyprus, in 90 B.C.; in Italy, in 80: in China—mountains having disappeared in many places—in 57, and again in 47: in Palestine—when 30,000 persons were killed—in Lydia, Ionia, Thebes and Egypt, in 31 and 30; in Cyprus, in 26; in Italy, in 21, and, in the Island of Cos, in 10, B.C.

* *Report of the British Association for* 1852.

We have now arrived at the commencement of the Christian era, and we will, in accordance with the plan previously pursued, first consider the pestilential diseases that occurred subsequently, and then the atmospherical and cosmical phenomena.

Pestilence prevailed in the East, in A.D. 14 and 16, having been preceded by famine, and again in 46.* In Rome, 30,000 people were carried off, in 68, in the course of three months. This was followed by a murrain among cattle. It was then, also, that pestilence and famine prevailed to so fearful an extent in Jerusalem, while besieged by Titus and Vespasian. In 80, a pestilence in Rome carried off 10,000 daily for some time; and it raged in the north of England and in Scotland, in 92,—the mortality, in the latter country alone, being set down at 150,000. In the beginning of the next century, or in 114, a pestilence, which destroyed 40,000 people, sprung up in Wales; caused, it is said, by the putrefaction of dead fishes cast on the sea-shore. By this we are to understand, that the finny race was affected at the same time as man, if not with the same disease, at least by the same cause. A pestilence prevailed in Africa, in 118, according to Fracastero; in England, in 137; and in Arabia, in 138. It devastated several provinces of the Roman Empire in 141, during the reign of M. Antoninus; and again in 158, as, also, Asia Minor and Arabia. Previously to this, or in 146, a destructive plague prevailed in Scotland.

Shortly after this, commenced the first general pestilence that has been recorded: it continued in Europe from 167 to 200. It is said to have commenced in Asia in 161; and to have spread thence to Europe, committing such ravages, during its course, that scarcely a third part

* It is to be understood that all the years, subsequently referred to, belong to the Christian era.

of the population was left alive. Short states, that it visited Wales in 169, and England in 174. In Rome, 5,000 died daily in 192—the disease being attributed to the introduction of *poisoned needles* into the people's bodies. The commencement of the third century was less fatal to men and animals than the termination of the second. But pestilence prevailed in Rome, and other parts of Europe, in 216; and in Scotland, in 222, when 100,000 persons were cut off. A great mortality of fish was noticed at the same time—multitudes having been cast ashore on the coasts of Great Britain. Previously to this, or in 218, there was "a mortality of all the reptiles, cattle and horses, in Great Britain." (*Iolo*, Welsh MS.)

In the middle of this century, the second general pestilence, after Christ, commenced; and continued for fifteen years. It is said, in the *Universal History*, that it ravaged Cappadocia, and the whole of Asia Minor, and to such an extent, that there was scarcely a province, a city, or a house, that was not attacked and desolated. The disease, during this visitation, was a species of cholera, being attended with continual vomitings, and extraordinary evacuations. It spread to nearly all countries; and Gibbon calculates, that "a moiety of the human species fell a prey, at this period, and in the course of a few years, to war, pestilence, and famine." In Scotland, the living were scarcely able to bury the dead. At the commencement of the next century, a fatal disease, attended by anthrax, or carbuncle, prevailed in Italy; and a pestilence, no less fatal, broke out in England and Wales. In 325, pestilence was again general, in Asia, in Europe, and in Britain; as, also, in 336, 355, 358, 362, 367, 368, and 375. In the last-named year, 43,000 persons are reported to have died in Wales. In the following year, a murrain, which began in the East, spread to the West, through Dalmatia, Hungary, France, and the Low Countries.

Having thus given a summary of the pestilences that prevailed during the first three centuries of the Christian era, we may now inquire what other phenomena were observed at this period.

In A.D. 6, there was a sore famine in Rome; and an equally severe one in Ireland, four years after. "Fruitless were her arbours, milkless her cattle." . . . "There used to be but one grain upon the stalk: one acorn upon the oak, and one nut upon the hazel." This lasted during the five years that Calibre was in the sovereignty. In 14, there was a famine in Italy; and in Syria in 46, having been foretold by the prophet Agabus. (Acts 11. v. 28.). The same calamity was felt in England, in 57, and in Ireland, in 76; at which time, "this island was without corn, without milk, without fruit, without fish, and without every other great advantage." In England, a grievous famine occurred in 54, and again in 151 and 160. In the last year, multitudes were starved. In 228 and 238, thousands perished from starvation in Scotland; and in Wales, in 259. In England, in 272, bread was made of the bark of trees; and famine was again grievous and fatal in Scotland for 4 years. In 334-5, occurred "a dreadful famine, of which more than half the British population died." (*Iolo.* Welsh MSS.) Some years later, a long and severe famine prevailed in all the Roman provinces; and particularly in Phrygia, in 376; in consequence of which those that were left alive abandoned the country. The same calamity was experienced in Wales, during this and the preceding year; and it is stated, that 40,000 perished from the combined effect of famine and pestilence.

As regards atmospherical phenomena, the commencement of this era was characterized by heavy and long-continued rains, and an overflow of the Thames, by which 10,000 persons were drowned. Tacitus states, that so much *red* rain fell in Albania, in 68, that the rivers ran blood ; and the same phenomenon was observed in Egypt in 65.* Multitudes of cattle, it is said, were swept away by an inundation of the Severn in 79 ; while people and cattle were drowned by a flood of the Humber, for 50 miles inland. The reverse of this, or great heat and drought, prevailed in 117 ; in consequence of which, or of the pestilential state of the air, such myriads of flies appeared, covering everybody and everything, and causing so much annoyance, that Trajan was obliged to abandon an expedition he had undertaken against the Agorini—a people of Arabia. In 137, a severe drought was experienced in England, so that the Thames was almost dry ; and the destructive plague, which raged in the East, in 158, was attended by great atmospherical phenomena—fogs, inundations, &c. So severe a winter was experienced in England, in 173, that the Thames was frozen over for *three* months ; and deep heavy snow covered the earth for 13 weeks. Heavy rains in England, in 218, caused an overflow of the Tweed, by which many people and much cattle were destroyed : and, in 233, it rained in Scotland *incessantly* for 7 months. In 245, a great inundation of the sea, in Lincolnshire, laid many thousand acres of land under water—an effect that may be ascribed to subterranean causes, concussions of the earth being very frequent at this period. During or preceding the pestilential outbreak that commenced about this

* In a storm, which occurred in the South of France, in October, 1846, rain, of the colour of blood, fell, together with a red dust. This consisted, according to Ehrenberg, of marine animalculæ. The probability therefore is, that these animalculæ were carried up by a whirlwind on the Mediterranean sea, and were then transported, by the upper currents of the atmosphere, to the place where they fell.

time, mists and exhalations of a peculiar character were observed. According to Cedrinus and Eusebius, they resembled the *ichor* of dead bodies, and were hence termed *ros tabidus*. A tremendous frost is stated to have occurred in England and Wales, in 291; followed by a famine which lasted several years. A remarkable drought, no rain having fallen for 36 years, is mentioned by Petavius as having commenced in the island of Cyprus in 314. Hurricanes, thunder, and hail storms, were frequent and severe at this period. In 67, much people and 15,000 houses were destroyed by a hurricane in England; 200 houses and many men in Canterbury, in 234; 900 houses in London, in 253; and 420 in Carlisle, in 349. Pickering and Caerlon were burnt down in 8 and 24 by lightning; part of Winchester, in 52; do Edinburgh, in 60; do. London, in 69; do. Canterbury, in 84; do. Camelon (the Picts' chief town), in 98; do. Chester, in 111; and many other towns, between this and the end of the 3rd century. Hail storms were also frequent and severe, particularly in 135,—the hailstones being 12 inches round; in 264, when they weighed 1lb. each; and again, in 344, when men and cattle were alike killed, the stones being as large as goose eggs.

"Cosmical Phenomena." In A.D. 15, an earthquake caused great havoc in Rome; and another, in 17, in Asia Minor. Tacitus states, that thirteen cities of note were overthrown by the latter; and chasms formed which swallowed up the inhabitants. Fire issued from the earth; mountains became plains, and plains were elevated into mountains. The earthquake that occurred in Palestine, in 33, at the Crucifixion of Christ, was, as will be remembered, attended by darkness. The year 40 was memorable by an eruption of Etna, causing Calicula to fly out of Sicily. Hieropolis and Laodicea were overwhelmed and destroyed by an earthquake, in 60 or 62; and a severe one was felt in Italy the following year—at Pompeii, Herculaneum, and Naples. Another in Campania, in 68, was attended by a violent tempest, and by the discharge of a pestiferous vapour, which, according to

Seneca, destroyed 600 sheep. Concussions were felt, the same year, in England—at which time, it is supposed, the Isle of Wight was separated from the main land; in Cyprus, in 78—three cities being overwhelmed; in Misenium, in 79—when the sea suddenly receded; and, the day after, the first eruption of Vesuvius took place: in Asia Minor and Greece, in 105—three cities being destroyed in the former region, and two in the latter; in Galatia, in 106—three cities being overwhelmed; in England, in 110; in China, in 115—the shocks numbering 107; and in Antioch, in 117. In this earthquake, nearly all the houses in Antioch were demolished, and other cities entirely destroyed; much people perished; mountains and hills became plains; rivers were dried up: and springs burst forth, where none were before. It was preceded by darkness, so that "one could not see one another;" and by a violent hurricane, attended with thunder, lightning, and thunderbolts, to the destruction of buildings and of men. Nicomedia and Nicca were partially destroyed, in 121; and Nicopolis and Cesarea entirely so, shortly after. During a concussion in Dorsetshire (England), in 131, the sea rushed twenty miles inland, drowning a great many people. Minor shocks continued to be felt, in various countries, between this and 204, when a town in Brecknockshire was swallowed up; soon after which, or, in 223, Antioch was again shook and overwhelmed in ruin. It is stated by Evagrius, that 300,000 persons perished in this catastrophe, and, among them, Euphrasius, the Bishop. A conflagration followed, and consumed what was left of the city. Several cities in Asia Minor were nearly destroyed by an inundation of the sea in 262; and Tyre and Sidon, by concussions alone, in 272. Worchester, in England, was also nearly destroyed by the same cause, in 287. Busiris and Coptis—cities of Egypt—were overthrown by an earthquake, in 290; twelve towns in Campania, in 336; several, in Asia Minor, in the years [illegible]0, -42, and -43; and 150 levelled to the ground in Asia Minor, Bithynia, and Macedonia, in 359. Concussions were again felt in Constantinople and Asia Minor,* in 363; and in Greece and in Egypt, in 365—a sea-wave being produced by which 60,000 persons were drowned in Alexandria alone. In other places, the sea receded, and left its bed a highway for passengers. Minor effects of the same kind continued to be felt in Asia Minor, Greece, and Europe, between this and the end of the century.

* This was the year, when Julian attempted to rebuild Jerusalem; but subterranean fire, which burst forth from the earth, destroyed the works, and rendered the place inaccessible.

Having thus narrated the principal events connected with the subject under consideration, during the first three centuries of the Christian era, we may turn to those that occurred during the subsequent centuries.

From 400 to -19, Asia, Africa, and Europe, were scourged by a plague. Nicephorus states, that "almost all Europe perished" at this period. In Wales, so great a mortality was produced by what was termed the "yellow pestilence," from the colour of the skin of those attacked, that unburied bodies lay over all the face of the country. Famine, according to Lingard, prevailed at the same time. This, or another pestilence, swept away great numbers in England, in 436 and 442; and again in 446, the ravages of the disease, in the last named year, being increased by a famine. It was at this time, that St. Patrick is reported to have kept a leper in his house—the first notice we have of this disease in Ireland. A plague prevailed in England, in 444, and in Asia, Africa, and Europe, in 448; the ravages of the disease in these regions being so great, that the living could scarcely bury the dead. It had been preceded by an abundance of provisions, but was followed by a famine, so severe, that even parents devoured their own children.* Multitudes of fish perished at the same time. In 465, says Henry, a pestiferous smell, or vapour, in the air killed both man and beast. Epidemic diseases infested Scotland, in 480; and raged among men and animals; while Asia and Africa were nearly depopulated. At the beginning of the next century, or in 502, Scotland was again visited; and, in the following year, an epidemic, which exhibited all the symptoms of true plague, broke out in Marseilles—the first account we have of the existence of such a

* Bede, *Ec. Hist.* p. 51, and Baronius, vol. 6, p. 30.

disease. There was pestilence in Wales, in 527, and again from 531 to 537.

We have now arrived at the commencement of the great epidemic constitution of the sixth century; characterized by the appearance of plague, measles, and malignant sore throat. "Then," remarks Short, "was the terriblest and greatest plague over all the world, that ever was paralleled or recorded in history. It began in the East, thence it spread over the globe, not missing one corner, nor did it seize the same person twice."* During this march, "it observed," remarks Precopius, "a sort of regularity, so that it remained about the same number of months in each country; commencing always by those places nearest the sea, from which it advanced regularly to those at the greatest distance, and ravaged them all. If it passed by a particular country at first, or *slightly affected it*, it soon returned to it with the same desolating rage, which other places had experienced" (*Lib.* ii. c. 22). And he adds; "it ravaged the whole world, seizing all descriptions of people, without regard to difference of constitution, habits, or ages; and without regard to their places of residence, their modes of subsistence, or their different pursuits. Some were seized in the winter, some in the summer; others in other seasons of the year."† In Constantinople, the disease lasted four months, raging, for three months, with extreme mortality, and carrying off, when at its height, 10,000 daily. The epidemic, however, did not subside altogether for fifty years, spreading from place to place, and returning to those spots that it had previously passed over. It traversed Italy and France in 543, -46 and -49; and committed great ravages in the army of the Goths, in 547, while besieging Rome. The plague is stated to have commenced in Ireland in 534, but the date must

* *History of the Air, Weather, and Seasons.* † *Hist. Eccles.* lib. 4, c. 29.

be erroneous, as this disease did not break out in England until 544 or -5, and in Wales until some years after. It has, no doubt, been confounded with another disease, that prevailed in 540, and was called the "yellow pestilence;" "because it occasioned all persons, who were attacked with it, to be yellow and without blood." This form of plague was again very prevalent in Ireland and Wales, in 547 and -48; Maelguin, King of North Wales, who had retired to his castle in Ros to avoid the pestilence, having died of it. We have no account of its prevalence in other parts of Europe, although Owen Pughes states, that the yellow plague—*y-fall-felen*—raged over a great part of the world in the 6th and 7th centuries.* But this is an error, as there is no record of such a disease in other countries at this period. A pestilence, which, says Short, was ushered in by a bloody rain, in 535, prevailed in England, and in Wales in 536: but this would appear to have been merely the forerunner of the plague, that followed subsequently. We may draw the same conclusion with respect to the disease, that prevailed in Ireland in 534.† Evagrius, who remarks, that this plague was the longest that ever appeared in the world, adds, that some cities were left without an inhabitant, while other districts were only slightly visited. He also mentions, that sporadic cases were sometimes observed—one or two families perishing, while the rest of the city escaped. The same result is observed, in the present day, in Turkey and Egypt, the importance of which,

* *Welsh Dictionary.*

† These visitations in Great Britain and Ireland are particularly interesting and important, as demonstrative of the spontaneous origin of diseases. Not only could there have been little or no intercourse between these Islands and other parts of the world at this period, but, while plague sprang up in the East, another and different disease, or yellow fever, made its appearance in the West. The latter, therefore, could not have been imported.

as respects the doctrine of contagion, has been pointed out in the first part of this work. "In some cities, it attacked certain parts of the town, and left others untouched. But what appeared singular and surprising was, that the inhabitants of infected places, removing their residence to places where the disease had not appeared, or did not prevail, were the only persons who fell victims to the plague in these cities." These persons must have imbibed the seeds of the disease on the spot from which they fled; but the exemption of the inhabitants, among whom they resided, is another proof among a multitude of others, that plague is not propagated from man to man. Another fact mentioned by Precopius is, that "neither physician nor attendant caught the disease"—a common result in all epidemics.

As previously mentioned, the epidemic period lasted fifty years, the disease prevailing epidemically in the following years, viz., in 542, -43, -47, -58, -62, -65, -82, -83, -87, and -90. The plague then disappeared altogether, for a time. Papon remarks: "we cannot understand why it did not last longer; since they neither disinfected nor burnt the clothes, or the effects of the plague patients." The same course is adopted in the present day, both in Turkey and in Egypt; yet the plague ceases, in the latter country, *invariably* the end of June, although half the population is then clothed in the garments of the dead.* In France, dysentery prevailed, at the same time, in every part, carrying off Austrigilda, Queen of Orleans; her two physicians being *put to death* for not saving her life! "In Wales," says the Book of Llandaff, "it raged not only against men, but against beasts and reptiles;" and was so fatal, that "the residue of the Welsh nation departed into distant countries." A murrain also prevailed in

* For the evidence on this point see Chapter I., Part I.

France and Italy, in 570, and, according to Marius, destroyed nearly all the cattle in these countries (*Episcop. Chronic.*). Plague broke out in Spain, in 589; and in Marseilles, in 590.* Papon says, its ravages were so great, that each house became a sepulchre, and the town a vast cemetery. In Spain, the air was charged with a fetid mist, which produced sneezing, and many died in the act. Hence the custom of saying, *Dominus tecum.* The same result was observed at Rome, in 581, when men died suddenly, at play, at table, and in conversation. It is also stated by Evagrius, that 80 persons dropped down dead during a procession, instituted, in 590, by Pope Gregory. During the last year of this century, the plague again committed dreadful ravages in the East, in Africa, and in Rome. Thus ended the epidemic period of the 6th century, "which," says Gibbon, "was marked by a visible decrease of the human species, that has never been repaired, in some of the fairest countries of the globe." It may also be mentioned, that leprosy prevailed epidemically in Ireland at the end of this century.

The beginning of the next century is memorable by the appearance of a new disease, or, at least, one of which we have no previous account. This is small-pox, which broke out in Mecca, in 610, and then spread over Egypt and other countries. Previously to this, the plague which, as already mentioned, re-appeared in the last year of the previous century, continued its ravages in this—in Italy, in

* In the following pages, the term Plague, or Black Death, will be applied exclusively to that form of disease which prevails now in Egypt and Turkey; and which was epidemic in Europe, until the beginning of the 18th century. For other epidemics, when not more particularly specified, the term pestilence will be employed. This distinction is not always made, although it was drawn by Prosper Albinus, an Italian Physician, who practised in Egypt in the 16th century.

Africa, and in the East. The Goths and Vandals, who were marching to besiege Constantinople, lost so many men, that they were compelled to abandon the enterprise. Their commander, Cayanus, lost seven sons. In 615, Elephantiasis was epidemic in Italy. From this period until the middle of the century, there was either an absence of pestilential diseases, or, else, a want of records, no particular outbreak being mentioned. But, in 639, the plague was so severe in Syria, in Arabia, and at Medina, that the Arabs, it is stated in the *Universal History*, call that year—"the year of destruction." In 656, the plague again made its appearance in the East, and spread to Europe. In England, however, the disease assumed the form of the "yellow pestilence," and was very fatal. It spread, also, over the whole of Ireland, leaving only every third person alive. In 664, the plague prevailed in Egypt, and pestilence in Normandy and England; and, in the following year, in Italy. The Anglo-Saxon Chronicle says: "There was, in 664, a great plague in the island of Britain, in which died Bishop Tuda."

In 675 began, what was termed the third mortality of plague, which soon became general in Europe. England and Ireland were ravaged in 679, and Rome in 680. It was so fatal in Rome, that, according to Paul Diaconus, "Parents and children, brothers and sisters, were borne to the grave on the same bier." In Ireland occurred, at the same time, the "mortality of children," from what is termed the leprosy, or pox, evidently the small-pox; and which may be regarded as the first appearance of the disease in that country.* Adamnan states, that a mortal disease, in 684, devastated, for two years, the different countries of Europe—Italy, the Cisalpine Alps, Gaul, Spain, and, in fact, everywhere except among the Picts

* Florence of Worcester's *Chronicle*.

and Scots, "between both of whom the 'Dorsi Brittanici' mountains were the boundary."* In 685, also, "a great outburst of pestilence, with wide-spread death, devastated Britain." In 686, during the reign of Cadwaller, the Britons were attacked with a pestilence, which, in a short time, destroyed such multitudes of people that the living were not sufficient to bury the dead. Emigration followed, "so that Britain being now destitute of its ancient inhabitants, excepting a few in Wales, that escaped the general mortality, became a frightful place even to the Britons, for some time after."† It prevailed, at the same time, in Ireland and in Syria, and lasted three years. In addition to pestilence in man, there was "a mortality upon all animals, in general, throughout the whole world for the space of three years; so that there escaped not one out of the thousands of any kind of animals." A great destruction among birds is mentioned as having occurred in 671, in England; "so that there was an intolerable stench, by sea and land, arising from the carcasses of birds, both small and great."‡ A murrain ravaged Ireland, in 684; and, in 694, there was, to use the language of the day, "a great morren of cattle throughout all England." It prevailed again in Ireland, in 695, and produced so great a dearth that, according to the Annals of Clonmacnoise, "for three years together, men and women did eat one another."

We will now consider the other phenomena that were observed, during the three previous centuries. At the commencement of the 5th century, so severe and general a famine prevailed, that the populace demanded, says Baronius, that human flesh should be sold in the market. This want of animal food was the effect, no doubt, of the murrain that prevailed at the end of the previous, or 4th,

* *Vita Columbæ.* † Geoffrey of Monmouth's *British History.*
‡ Ethelward's *Chronicle.*

century. A famine, accompanied by pestilence, raged in Spain in 443; it was so general and so severe, that men, says Masdeu, became anthropophagists, and devoured each other with fury. The same result, from the same cause, was observed in Asia and Africa, in 450; so that parents devoured their own children. In 466, a grievous famine, which had been preceded by a murrain, is recorded to have taken place in Great Britain; and another famine—termed a *perditio panis*—ushered in the 6th century; a third, which commenced in Wales, in 531, became general in 534, not only in Great Britain but in Europe. It is recorded as one of the most distressing, that ever afflicted the earth; multitudes of the human race having been destroyed.

As regards abnormal atmospherical vicissitudes, during the preceding period, we find that one of the most severe winters on record occurred in 400. The Euxine Sea was covered with ice for 20 days. The same period is marked by deluges of rain, inundations of rivers and of the sea, followed by intolerable cold and storms of hail. To these succeeded a drought, which blasted vegetation and produced a famine, during which multitudes of people perished. In 443, the snow fell to such a depth, and continued so long in Illyricum, that multitudes of men, women, and children perished. A severe drought—*ingens siccitas*—followed, in 450, and the calamities incident thereon continued for some years. To this succeeded, in 465, such deluges of rain, that whole towns in Bithynia were swept away. In 484, occurred a most terrible and distressing drought—not a vine or an olive branch retained its verdure; the earth, says Baronius, was desolate; and the sun assumed a melancholy aspect. (Vol. 6, p. 426.) It raged with double fury in 539, and Precopius states, that 50,000 labourers died of hunger in the narrow region of Picenum. Mothers eat their own children, and, in one place, 17 travellers were murdered and eaten. This famine would appear to have been produced by a failure in the crops, rather than by murrain. Baronius says: "The crops failed: corn ripened prematurely, and was thin: in some places it was not harvested (being blighted or destroyed, we may presume); and that which was gathered proved to be deficient in nourishment. Those who subsisted upon it became pale, and were afflicted with bile. The body lost its heat and vigour; the skin became dry; the countenance stupid, distorted and ghastly, while the liver turned black" (*lib.* 7, p. 326). It is worthy of remark, that no pestilence occurred during this period, or until after the famine had subsided. Bede mentions the same fact, with respect to the famine of 466, and he adds: "Subsequently, when plenty abounded, and luxury increased, a severe plague fell upon that corrupt generation. It destroyed such numbers of them, that the living were scarcely sufficient to bury the dead." The 6th century was ushered in by a fall of bloody rain in England, followed, in other countries, by great heat—a drought for five years, in Palestine, having been recorded in 517. In 553, the winter in Europe was so severe that wild animals and fowls might be taken by the hand. In 562, an extraordinary drought spread over the whole world: but, in 582, great inundations, caused by heavy rain, occurred in France. The same result was experienced in Rome in 590—the inundation covering even the walls of the city, and lodging innumerable reptiles on the plains. In the next summer, happened one of the severest droughts ever known in Europe—no rain having fallen from January to September.

Few meteorological facts of any importance have been recorded during the first half of the 7th century. In Wales, the "yellow pestilence" of 640 was ascribed to "a column of watery cloud, having one end trailing along the ground, and the other in the air; progressing in the air, and passing through the whole country, like a shower." This was evidently a water-spout—a rare phenomenon in a mountainous region, and so far inland. Meteors, which have always been observed at epidemic periods; and which are evidently connected with telluric influence, were very common at this time. Referring to the connection between earthquakes and meteors, Van Hoff observes: "A somewhat nearer connection may be supposed to exist between earthquakes and phenomena of this kind . . . . To this class belong the so-called globes of fire, and other extraordinary lights and illuminations in the regions of the air, which cannot be considered as belonging to the ordinary methods of electrical discharge." (*Gesch. Veran. Erdober.* Th. iv.). And Humboldt states, a shower of meteors was observed just before the earthquake at Cumana in 1766; at Riobamba in 1797, and again at Cumana in 1799. (*Cosmos,* Notes 44, 45). Mr. Mallet mentions the following years in which meteors have appeared contemporaneously with earthquakes viz., B.C. 95 and A.D. 893, 1001, 1325, 1640, 1674, 1683, 1703, 1737, 1752, 1756, 1810, 1820, 1821,-22,-24,-28,-29,-31,-33 and 35.* In 671, violent storms destroyed men, cattle, and all the fruits of the earth, except leguminous plants. Famine followed in the train of these events. A severe drought, which, says Bede, lasted *three* years, and was accompanied by famine, commenced in England in 680. In Italy, on the contrary, long-continued rains, and frightful storms, prevailed this year, and accompanied a plague that then ravaged Rome. Two years after, or in 685, it rained blood, as the term is, in Great Britain; and

* First Report, *loc. cit.*, p. 74.

in 688, this red coloured rain continued for seven days, and butter and milk turned to blood. The moon, also, was of the colour of blood. Great storms were experienced, and a grievous famine followed. In 690, great inundations occurred in Italy—the greatest ever known there—but, in other places, the cold was equally remarkable and exceptional. In 695, the frost was so great, that *the sea between Ireland and Scotland* is said to have been frozen over; "so that people (on the opposite sides of the Straits) paid reciprocal visits to each other."—*Chronicon Scotorum.*

We may now turn to the cosmical phenomena, that were observed during this period, respecting which we have more detailed accounts.

Earthquakes occurred in the following places, and in the undermentioned years. In Rome, in 408; in Asia Minor, many towns being destroyed, from 417 to 419; in Constantinople, and many other places, in 422 and 423; and, again, in 427, 434 and 444; and over all the world,—i. e. Asia Minor, Turkey, Africa, and Europe, in 446. The shocks lasted six months, and the walls of Constantinople, with five towers, were thrown down; islands disappeared in some places, and the sea receded in others; leaving ships high and dry on the land, while the fish perished in great multitudes. Earthquakes were experienced in Gallicia and Spain, in 448; and again in 455; in Constantinople—the shocks being violent—in 450; in Asia Minor and Antioch in 458, a great part of the town being laid in ruins; while the shock was felt throughout Thrace, the Hellespont, and the Greek isles; in France, in 468; in Asia Minor—several cities being overthrown—in 471; in Constantinople, the Island of Cos, and Rome, in 477; in Constantinople, in 487; and, in Asia Minor and Syria, in 498—when Laodicea, Hieropolis and Tripoli were overturned; as was, also, Neolessarea, in Pontus, the following year. During this century, there were two volcanic eruptions,—that of Etna in 420; and that of Vesuvius in 472.

The 6th century was ushered in by another, the 4th eruption of Vesuvius. Previously to this, the sun assumed a pale colour, shone with a feeble light, and appeared as if eclipsed. This phenomenon, which is common previously to eruptions and earthquakes, denotes the presence of an extraneous matter, or vapour, in the atmosphere. The eruption was followed, in 518, by a series of earthquakes in Mæsia, which demolished 24 castles, and separated mountains. After this, earthquakes occurred at Corinth, in 522; at Antioch, in 525—250,000 people having perished during the concussion; at Constantinople and Libanus, in 533—when a great sea-wave was produced, and a part of the latter town engulfed; throughout the known world—or Asia, Asia Minor, Africa and Europe—in 543; in Turkey, in 542,-6 and -48; in France, in 549; in Palestine, Mesopotamia, Arabia, and Greece, in 550-52; in Constantinople—the shocks lasting 40 days—in 554; at Cos, Tripoli, Berytus—which was destroyed—and Rome, in 557; at Constantinople, in 558,-60; and in Ireland, in 561, as "a poisoned pool made its appearance in Meath, through a chasm of the earth, and a vapour proceeded from it, which produced a fatal disease in man and beast." Again: a concussion occurred in France in 562,—when the *Dent du Midi* fell in, burying a number of houses; at Antioch, in 570; in the South of France, in 580; and, again, in 582; at Rome, in 586; at Antioch, in 587 and -89, and, in France, in 590. Terrestrial concussions commenced the first year of the 7th century in Japan; were felt in Constantinople, in 611; more severely in Italy and other places, in 615;* in Palestine and Arabia—the shocks lasting 30 days—in 632; at Antioch, in 639; in Medina and Arabia, in 640; and, again, in 650; in Palestine and Syria, in 658; in England, in 660 and -63,—preceded, or accompanied, by two "darkish or darkened" days; in Turkey and Mesopotamia from 677 to 680, and in Japan, in 684, when 500,000 acres of land were submerged. In 685, the 5th eruption of Vesuvius took place.

At the commencement of the 8th century, pestilence broke out in England, Ireland, and Scotland; and was accompanied by a famine. This famine may be ascribed to the murrain that prevailed at the end of the previous century; and which was prevalent again in Ireland in 707. The pestilence, or plague, raged, at the same time, in other parts of Europe and in the East. It carried off so many, in Brescia, in 709, that people could not be

* Nearly all writers refer to the dreadful concussions of this year.

found to bury the dead. In 717, the Saracens, who were marching to besiege Constantinople, perished in vast numbers; while 300,000 are said to have died in the city itself. It was about this time, or in 714, that the small-pox appeared in Spain for the first time. Plague prevailed again in Constantinople in 724, in Syria in 732, and in 740, during the reign of Leo the Isaurien. This was the commencement of another pestilential epoch which continued for 260 years. It raged in the East and in Europe at the same time. In Constantinople, Naples, and Calabria, the living were scarcely able to bury the dead. Fatal indeed must have been the disease, when, as we are told, the man who buried a corpse was sometimes carried to his grave on the same day; "*Eadem die aliquis mortuum efferebat, et ipse mortuus efferebatur.*" In England and Wales, the epidemic was no less fatal—34,000 persons, according to Short, having perished in 766, in Chichester alone. Constantine, the successor of Leo, was attacked and died of plague in 775, during an expedition into Bulgaria. It committed its usual ravages, at this time, in Greece, Sicily and Italy, and caused a fearful mortality in Pavia, then besieged by Charlemagne. In the 1st year of the next century, the plague spread over Italy, France, and Germany; while a murrain raged in France. It was attributed to poison, sprinkled over the pastures by the emissaries of the Duke of Benevento.* In 810, "there happened," according to the Welsh Annals, "the greatest mortality among horned cattle in Britain, that is on record." It came from the East, or from Hungary and Illyria, and then spread through Austria, Germany and the Low countries. So great was the mortality among the cattle in the Army of Charle-

* This suspicion arose, no doubt, from the blue mist and deposit, so frequently observed at such periods.

magne, during his expedition against the Scandinavians, that scarcely one beast was left alive. It was no less destructive in the dominions of the Emperor,* having destroyed almost all the cattle in some parts of Germany. Short states, that "the year 823 was fatal to both men and cattle in England," and it was no less so on the Continent. The mortality was such, that the greater part, it is said, of the inhabitants of France and Germany perished. This murrain, like the previous one, first appeared in Hungary, and then spread westward. Pestilence in man, and murrain in cattle, returned in 852, and caused great calamities throughout the world. Another outbreak, which was productive of a fearful mortality among men and cattle, prevailed in England in 868, and throughout the whole world.† Myriads of locusts, of a remarkable size, appeared in France in 874. They travelled at the rate of four or five miles an hour, and devoured every green herb and tree on their march. They were ultimately driven into the channel and perished. There was another murrain among cattle in England, in 884; and, in 896, anthrax, or carbuncle, became epidemic in Europe, attacking both man and beast. It was particularly fatal in Italy. In England, the murrain in cattle, together with pestilence in man, commenced in 897, and continued for three years; but it did not break out in Ireland until the following year. It prevailed at the same time in Germany, and was very fatal.

Early in the next century, or in 922, Scotland was ravaged by the plague; France and Germany, in 927, and England, in 937. Scotland was again visited in 949, when 40,000 persons were carried off. A Spanish king, Don Fruela, 3rd son of Alfonso the Great, died of

* *Chronique de St. Denis.* † Asser, *de rebus gest. Alfredi.*

leprosy, in 923, from which time the disease became more and more common in Spain, until leper houses were established all over the country. In 940, a murrain again spread through Italy, France and Germany, and extended, in the following year, to the north of Europe. It prevailed in all these countries until 942. About this time, or in 949, the first mention is made of a disease supposed to be lues venerea; while another new and mortal disease, known as the "*faim canine*," prevailed in France. In 956, "innumerable multitudes," says Short, "died of the plague in England," the same as elsewhere; and it prevailed again, in 962, in London, during which Paul's Minster was burnt down, and, with it, a considerable part of the town. A destructive murrain is stated to have prevailed in Italy in 960; and in 986, "a mighty mortality took place among the cattle over the whole island of Britain." It spread to Germany in 992. The plague had prevailed in the human race, both in Italy and in Germany, some years before, but in the last-named year, a severe and deadly epidemic of ergotisme (*feu sacrè*) sprung up in France. Lastly, in 995, "raged epidemically and fatally, such a disease as the English had neither known nor felt for 200 years before, viz. a flux (dysentery), which made terrible destruction of men and cattle." (*Short*). Curiously enough, while Ireland appears to have been nearly exempt from murrain in the 9th century, England was equally so in the 10th—no mention being made of any visitation from 897 to 986. And yet, murrain prevailed in Ireland in 903, -8, -18, -50, -53, -55, -60, -81 and 92. This shows that, although these diseases generally spread from country to country, they spring up, at other times, in isolated spots and countries spontaneously, and irrespective of contagion.

We must now return, in order to consider the other phenomena, that occurred during the preceding epoch. At the commencement of the 8th century, famine prevailed in Ireland, and was so severe, that "man ate man," as it is expressed in the "Annals of Ulster." The same scarcity was felt in England and in Scotland, but not to the same extent. In the next century, or in 855, a severe drought and murrain caused such a scarcity in Italy and Germany, that "parents eat their own children, and children their parents." Famine was general again in Europe, in 867 and 897, and in 912 in Germany; in 944, in France and Germany; in Ireland, and on the Continent, from failure of the crop, in 968, and, generally, in all countries from 981 to -7.

As regards atmospherical phenomena, a great drought was experienced in Great Britain in 713-14; and in the following year, it rained "honie" in Donegal, "silver" in Olhainmor, and "blood" in Leinster. Repeated mention is made, at this time, of fiery dragons seen in the air; and, according to Smart, of fiery stars and battles in the air all night; such as this age had never seen before. These phenomena are indicative of great and unusual electrical disturbances in the atmosphere at this period. In 742 and -3, being, it may be remembered, the commencement of the pestilential epoch before considered, a severe drought, followed by fearful thunderstorms, occurred; and, after this, extreme cold. In 744, the snow that fell in Ireland was so great, that "almost all the cattle were destroyed." A severe frost, attended by a deep snow, commenced in England in 763, and continued from October to the following February, at which time the Black Sea and the Dardanelles were completely frozen over—the snow and ice accumulating to the depth of 30 cubits! The succeeding summers, according to Baronius, were remarkable for extreme heat and drought; particularly in 767, when the springs and rivers were exhausted and dried up. In England, there was a visitation of venomous flies, "which *slew* much people." In 766, "it rained blood in England for three days;" while blood spots (*signacula*) were very general at this period; and it was considered, that those on whose clothes they appeared were more susceptible than others to attacks of leprosy. Hence the name *lepra vestium*. These spots not only appeared on all kinds of articles, and on the clothes worn by men and women, but, also, on those in closed chests. The spots were of all colours, red, white, yellow, grey, and black, but principally black. These atmospherical phenomena continued until the end of the century, and were followed by a severe famine.

A violent tempest, which did immense mischief in Africa, occurred in 800. It destroyed an infinite number of houses, and whole towns and villages, by its extraordinary force; and was followed by great inundations. Whirlwinds, and, what Short terms, dreadful forewarnings over the land, and fiery dragons, flying across the firmament, were observed in England at the same time. Extraordinary thunderstorms occurred again in Great Britain, in 804, also in Ireland; no less than 1010 persons having been killed by lightning, in what was then termed the country of Corka-Bascoin. Deaths from lightning would appear to have been unusually common at this period—several kings, nobles, and ecclesiastics, having been mentioned, in the Irish Annals, as having fallen victims to this agent. Severe cold was experienced in 820, the Rhine and the Danube being frozen over with solid ice; while, in 821, the snow lay on the ground for 29 weeks, causing a great loss of men and cattle. The like destruction occurred in the following year by hail storms. To these phenomena succeeded, in 823 and -4, a severe drought, followed as usual by famine; and another severe drought in 855, caused a failure of the crops. Hence the severe famine of this year. Instead of heat, great cold was experienced in 859—the Adriatic being so completely frozen, that carriages passed over it. Inundations followed, caused, we may presume, by the melting of the snow, and by heavy falls of rain, it being mentioned that bloody rain fell in Italy for three days and three nights. Excessive heat and drought, in 872, destroyed the grain crops; and severe hurricanes, that were experienced in Ireland, in 888 and -89, levelled churches as well as houses to the ground. Swarms of locusts followed, and added to the calamities produced by the preceding causes. They appeared in France, in 874; and then spread to England, Wales, and Ireland, being the first mention of locusts in the latter island. In 897, there was another visitation of these migratory insects in Ireland; on which occasion, "they left neither corn, nor grass, nor food, for man or beast."

Atmospherical aberrations were noted at the commencement of the 10th century, the same as the preceding ones. In 902, -5, -9, and -10, *two* suns were visible at the same time; while, on other occasions, this luminary was of the colour of blood—effects that may be referred to the presence of mists in the atmosphere. The winter of 929 was marked by severe cold, and the Thames was frozen over for 13 weeks; but, in 936, great heat and a severe drought prevailed. In 974, the island of Loughkyme, in Ireland, is stated to have been sunk by a great whirlwind. This was not an uncommon occurrence in this island, at that time, and the Census Commissioners state, that many of these submerged islands have been discovered of late years. The catastrophe is, probably, to be referred to an earthquake, not to the whirlwind, which must be regarded as an effect of the same cause as that which produced the earthquake. In 993, there was an excessively severe winter; the rivers were frozen dry, the fish perished, and the springs failed. A severe frost in July gave to the trees the aspect of winter. Unusually severe thunderstorms occurred towards the end of this century; and it is stated, that, in 995, "fire fell from heaven upon Armagh, and Ard Macha, which spared not (i.e. destroyed) *without burning*, houses, oratory, stone churches, and other buildings. There came not, in Ireland, since it was discovered, and *there never will come*, till the day of judgment, a vengeance like it." *

The preceding effects were accompanied, as usual, by terrestrial commotions. There were earthquakes in Ireland, in 706, -20 and -29; in Italy, in 707; in Syria, in 713 and -19; in Ireland, in 720 and -29; in Asia Minor, Thrace, Nicomedia, and Bythinia, in 741—the shocks lasting for 12 months, and destroying several cities; in Arabia, in the desert of Saba, and in 600 other places, in 742; in Syria and Palestine, in 746 and -49—whole cities being destroyed, and others removed from mountain to plain, for a distance of six miles. A remarkable darkness, which lasted from August to October, was experienced at Constantinople at this period. Concussions—preceded by a severe drought—were felt in Ireland, in 758, and also in 768; in Alexandria, in 784—at which time the Pharos was overturned; in Bavaria, in 780; in Rome, in 789; in the island of Crete, Constantinople, and Sicily, in 795; and in Africa, in 800—many towns and villages being wholly destroyed. In England, an extraordinary darkness, which lasted 17 days, occurred at the time that an earthquake shook several places in the Mediterranean. Recurring to the cosmical phenomena of the 9th century, we find, that earthquakes occurred in 801, -2, and -3, in Italy, France, Germany, and Switzerland. In the first named year, the Basilica of St. Paul's, at Rome, was thrown down, together with many other buildings. In 815, there was a concussion in Thrace, which lasted five days! another in Germany, in 838; in Italy, in 832 and -37; in Germany, in 838 and -40; in France, in 842; in Italy, in 844 and -47—accompanied by severe storms; and in the following year, in Persia, Korassan,

* *Annals of the Four Masters.*

and Arabia, together with violent storms. In 858, -9, earthquakes occurred in Germany, Switzerland, Constantinople, Syria and Antioch—1,500 houses being thrown down in the last named city. In 860 and -61, shocks were felt in Europe—during which one of the mouths of the Rhine was closed; in Persia, Syria, and Constantinople — the shocks lasting 40 days; in Europe, in 870, -71 and -77, in which year the church of St. Alban, in England, was overthrown; in India, in 893—when the capital (the name not being mentioned) was destroyed, together with 180,000 of the inhabitants. There was also a concussion in Erivan, in 894, when 20,000 persons perished; and in Rome, in 890, when the Lateran Basilica was destroyed. Fewer cosmical phenomena have been recorded during the 10th century than, perhaps, any other. Whether this is to be ascribed to the absence of data, or to the non-prevalence of concussions, it is somewhat difficult to say. There was a concussion in Rome in 911; in Thrace, in 930; in Japan, in 931; in France and Germany, in 950; in the Caspian Sea and in Persia, in 957-8; in Egypt, in 965; in Germany, in 968; throughout England, in 974; in Italy, in 982, previously to the 6th eruption of Vesuvius; in Turkey, Syria, and Greece, in 986; in Damascus, in 992; and in Egypt, Germany, and other places, in 997.

We have now arrived at the commencement of the 11th century, which was ushered in by an epidemic of colic and boils. This was merely the prelude to the great plague, which commenced in 1005, and which desolated the whole earth. It continued for three years, and contemporary authors affirm, that more than half the human race perished. So weary were those who buried the dead, that the living, before the breath had left their bodies, were tumbled into the grave with the corpses. "Endless multitudes," says Short, "died of plague, in 1012, in England as well as in other countries." Papon states, that those attacked, in 1013, experienced a great internal heat, with an extraordinary and violent purging, and died almost immediately. The plague was again almost general in Europe, in 1016; and still more so in 1022, when men were struck down as by a stroke of lightning, and carried off in a few hours. In 1025, the plague broke out in Flanders and other places, and "swept away the greatest part of men." "A great mortality of cattle," in Ireland, is recorded in 1016, but the nature of the disease is not mentioned. Chorea, or choro-mania (St. Vitus' Dance), appeared in Germany in 1027, and thence spread over the Continent and to the British Isles. In 1033, pestilence commenced in England, and continued for three years; and in 1040, there was, in Ireland, "a mortality of cattle and swine" —the first swine mortality specially noticed in the Irish Annals. In the following year, "so much cattle perished in England, as no man before remembered; as well through various diseases as through tempests." There was also a great death and dearth of people and cattle in England, in 1047 and in 1049; while in 1054 "there was so great a murrain among cattle, as no man remembered for many years before."—*Anglo-Saxon Chronicle.* In 1065, several hundred thousand Scythians, marching on Rome, were carried off by plague or pestilence; and in 1067, the plague swept away a great part of the inhabitants of Egypt and Arabia. It was in this year, that Lazar houses were first established in Spain. From 1077 to 1079, pestilence committed great ravages in Italy, France, England, Flanders, and Russia. It was at this time, that nearly the whole army of the Emperor Henry was cut off in Rome by plague. Half the inhabitants of England, it is said, were attacked, in 1087, with a malignant fever or dysentery: while erysipelas broke out in France at the same time. It was not long confined to this country, but soon spread over the rest of Europe.*

* This disease was said to have been brought from the Levant by the Crusaders—another tale of the Contagionists, for the first

Erysipelas, although known to the ancients,* has not been mentioned as prevailing epidemically, and in a severe form, until A.D. 1089; and is described, by the historians of that period, as having descended on the earth, in the form of *a Dragon of fire*. It then assumed a most malignant form. Sigebert, who wrote in 1089, says: "The plague (*feu sacré*) made great ravages this year, particularly in the western part of Lorraine, where many people have been internally consumed by *le feu sacré*; they fall into a state of putrefaction; their intestines become black like charcoal; they die miserably, or else they have the still greater misfortune to live, after having lost their feet and their hands from the gangrene, that attacks these parts." In 1095, the mortality from plague was so great, in the whole of Europe, that it depopulated provinces and whole countries. In Ireland, "there was not such a pestilence in the kingdom, since the death of the sons of King Hugh Slane," who died in 660. "Some say, that the fourth part of the men of Ireland died of it"—(*Tamh*, or plague).

During the latter part of this century, murrains prevailed in common with pestilence in man. Thus, there was, in the year 1078, "great mortality of cattle" in Ireland, together with "great store of the fruits of the earth." In the Southern half of Ireland, "a great mortality amongst cattle" is recorded in the year 1084; and, in the next year, "there was destruction of men and cattle to such an extent, that certain rich people were made husbandmen." This murrain existed, at the same

Crusade was not *preached* until 1093; and the expedition could not have left Europe until some years after.

* Virgil speaks of it, while referring to a murrain—*contactos artus sacer ignis edebat.* (*Georg.* l. 3); and Celsus and Galen both mention such an affection.

time, in England; and "prevailed throughout the world"; *i.e.*,—in Europe, Asia, and Asia Minor. In the next year, "pestilence among the cattle," in England, was contemporaneous with disease among the finny race; and with a murrain of cows (*Bo-ar*, cow mortality) in Ireland. In 1087-8, there was great destruction among oxen, sheep, and pigs, in Ireland; while "a murrain made sad havoc among cattle" in England. The feathered race were swept off at the same time; while "the remainder of the tame fowls—as hens and geese—fled to the woods," in order, probably, to die there. Murrain prevailed again, from 1092 to -98, together with plague among men, and caused a great mortality in Italy, France, Germany, and England.

As regards the other phenomena observed during this century,* a great famine commenced in England, in 1005, "such that no man ever before recollected." (*Anglo-Saxon Chronicle*). It continued for three years, and, together with plague, devastated the whole earth. Whether this famine arose from disease in vegetables, failure of the crops from drought, or from murrain, it is impossible now to say. Probably, all these causes were in operation. Either the famine had not subsided, or else it had returned, in 1012, as Short states, that "endless multitudes died of famine and plague, in England and Germany," that year. Unusual and excessive cold was experienced in the winter of this year, and preceded the outbreak of plague in 1006. On the eve of St. Michel, 1014, came the great sea-flood, "wide throughout England, and ran so far up as it never before had done, and washed away many towns, and a countless number of

* As the facts increase and multiply as we proceed, it will be better to consider the whole of the phenomena, century by century, instead of, as before, by epochs.

people." This, we may conclude, was the effect of an earthquake; still, as no concussion was felt, or has been recorded, it has been placed among the atmospherical phenomena. A severe drought was experienced in England, in 1021, while in Ireland there were great hail storms—the stones being of the size of wild apples—as, also, showers of wheat,—the grain, no doubt, having been carried up by a whirlwind from some other locality. The drought of 1021 was followed, in 1025, by excessive and heavy rains, in Flanders; it having rained incessantly from October to April. Tempests, inundations, and famine, occurred in 1031: and, in 1032, came, in Ireland, "the wild fire (lightning), such as no man remembered"—a proof of the prevalence and severity of thunderstorms. Two years after, the cold was so intense in *the month of June*, that all the corn and fruit in England was destroyed. Violent tempests were experienced again, in 1039, which was called the year of *the great wind*; while, in 1041, "so much cattle perished as no man before remembered, as well through various diseases as through tempests." Hence, famine was general in England, in France, and in Germany, in 1043 and -4—an effect that was due, in part, to blight, for "corn was so dear, as no man remembered before." Intense cold followed these vicissitudes, 1047 being "the *great snow year*" in Great Britain; snow having fallen in England and Ireland from December 8th, 1047, to March the 17th, 1048, without cessation. "It caused the destruction of much cattle, of wild animals, of birds of the air, and even of fish." (*Cambrian Annals*). All the west of Europe suffered at the same time and in the same way. The following summer was characterized by severe thunderstorms; "the crops were blighted, and there followed great dearth and death of people and cattle." The famine, or "the want of bread," as it was termed, continued to

1053, when a "great wind" occurred again on St. Thomas's mass night. Another hard winter was experienced in 1063, when the Thames was frozen over for 14 weeks; but, in 1067-8 the frost was so intense, that this river was completely frozen from November to the following April—18 or 20 weeks. In 1069, "such a dearth was in England, that man did eat horse's, dog's, and man's flesh;" and in 1077, and for two years after, famine prevailed in England, Flanders, Russia, and Italy; while locusts committed great havoc in the last-named countries. This famine may be referred to disease in the vegetable, as well as in the animal, creation; blight and murrain being both general, at this time, throughout the world. This dearth had not subsided entirely in England in 1082; while it returned in 1087; when "many hundreds of men died a miserable death through hunger." A severe storm, attended by a thick mist, and followed by a concussion of the earth, occurred in London in 1088: a few days after this, a thunderstorm destroyed 500 houses and unroofed Bow Church; in 1093, large numbers of the inhabitants were swept away in Syria by inundations; and rains and floods were experienced at the same time in England—1094 having been called the rainy year.

As respects the cosmical phenomena during this century, concussions occurred in Rome, Poland, and other places, in 1001; in Italy, in 1005, when the monastery of Monte Cassino was thrown down, with many other buildings; and at the same time at Deimar in Irall, which was overwhelmed, and 10,000 persons buried in the ruins. This was followed by a great fall of snow at Bagdad. After this, concussions occurred at Lisbon, in 1009; in Germany, in 1012; in Poland, in 1016; in Rome and Lisbon, in 1017; in Bavaria and Switzerland, in 1021; in Damascus—when half the city was destroyed—in 1029; in Turkey, Palestine and Syria, in 1032; in Jerusalem—the shocks lasting for 40 days—in 1035; and in nearly the whole Roman Empire, in 1036 and -7. It was in this year, that the 7th eruption of Vesuvius occurred, during which lava was thrown out for the first time. An earthquake is recorded as having occurred in China, in 1037; also in Constantinople, in 1038; in Persia, Syria, and Italy, in 1040; in Japan, in 1041; in England, in 1043, -47, -48, and -49; in China, in 1057; in Germany, in 1059; in Syria, in 1063,—when the walls of Tripoli were thrown down; in Thrace, Asia Minor, Egypt, and Arabia, in 1064-66; in Palestine and Syria, in 1069—a sea-wave being produced at the same time; in Germany, in 1070; in England, in 1076; in France, in 1079; in Germany, in 1080; in Spain, Germany, and England, in 1081; in Turkey, in 1082; in France, in 1083—two shocks in the year; in France and Italy, in 1087; in Germany and Italy, in 1088; in England, in 1089 and -90; in France, in 1091, attended by thunder-storms; in Italy, Antioch, and Damascus, in 1092; in Italy, in 1096; in France, in 1098; and in England, in 1099. This ends the list of the phenomena observed in the 11th century.

At the commencement of the 12th century, or in 1103, a murrain in England was followed by epidemics in man—fevers, dysentery, and an erysipelatous fever, which caused a great mortality. It was attended with black, livid, spots, like the carbuncles in plague. These diseases were followed, in due course, by the plague itself, which appeared in 1111. But previously, or in 1110, there was, what Short terms, "a bloody battle of wild fowls, wherein great heaps were slain:" the battle being, we may presume, not with each other, but with pestilence and death. This is confirmed by the next account, for the same writer states that, in the following year, the tame fowls died, and fled into the woods; while murrain prevailed with the cattle, and fish died in the water. According to the *Anglo-Saxon Chronicle*, this was the greatest pestilence among cattle ever remembered. "The next year was a fruitful, or plentiful, one; but a very heavy and sorrowful time, by reason of a dreadful pestilence (the plague) among men." In 1120, commenced another pestilential epoch, which continued until the end of the next century. It was ushered in by a visitation, in England, of erysipelas, which prevailed so generally and so fatally, that one-third of the population, it has been computed, perished from 1120 to 1125. The plague followed, and spread over Europe, committing such ravages that, according to Baronius, it carried off one-third of the inhabitants of those countries visited by it. This outbreak did not subside for twelve years. In 1115, there was a great mortality in Ireland among men, beasts, and birds; and, in the following year, a famine, "during which the man sold his son and daughter for food, and the people even ate each other." Murrain prevailed in England, also, in 1112, -15, -22, -25, and -31. In the last year, "there was so great a pestilence amongst animals, over all England, as had not been in the memory of man. It fell chiefly on swine, so that the man, who had possessed 200 or 300 swine, had not one left." This murrain, like the pestilence among men, lasted twelve years, from 1131 to 1146. The years 1133 and -34 were memorable in Ireland, also, by the great murrain of cows—the greatest that had been experienced for 432 years. "It left but a small remnant of the cattle of Ireland." The whole of Europe, also, suffered from a similar calamity, or a murrain, that prevailed from 1128 to 1130, if not longer.

The plague in man appeared again in 1150, and raged until 1169, in Asia, Judæa, Africa, Sicily, Italy, Gaul, England, Scotland, and Ireland. It was general, also, in 1171, together with a murrain, that prevailed both on the Continent and in England. Dysentery also produced considerable mortality, at this period, in England and Ireland; more especially in the army of Henry II., which was then in the latter island. Shortly after, epidemic catarrh ushered in the small-pox, measles, scarlet fever, quinsies, etc., which prevailed, at the same time, in the British Isles, and in all parts of Europe; as, also, in Asia and Africa. These diseases were followed, as will be found to have been invariably the case, with plague; which visited, not only all the countries before named, but Germany and Denmark, in 1181. In 1185, "A cruel pestilence," says Villalba, "appeared in Castile, and swept off a great part of the inhabitants. Its malignity did not spare the Palace; and rendered useless the precautions, that the great can alone take to protect themselves." In 1187, according to Short, "a grievous and pestilent mortality of men and cattle" prevailed in England, and continued until 1189; it re-appeared in 1193, and prevailed until 1196. Although we have no account of the plague in the East, or Asia Minor, a pestilence of some kind must have prevailed, as a thousand deaths occurred daily, in 1190, among the Crusaders at the siege of Acre. A few years after, or from 1193 to 1196, an acute and deadly fever raged in England. "It destroyed such numbers, that scarcely any were left to minister unto the sick."* This fever was prevailing in 1200, having returned, or, else, having continued up to this time.

Atmospherical phenomena in the 12th century. According to the *Saxon Chronicle*, 1103 was a very calamitous year in England, through deficiency of produce, not only in corn but in every kind of fruit; arising, we may presume, from blight. There was, also, a failure of the fruit in 1105; and the produce of the fruit trees almost entirely perished in 1110: while it failed again in 1113, in consequence of an unusual and heavy fall of snow. This period was characterized as well by heavy falls of rain and inundations, both on the Continent and in England. In Holland, 10,000 persons were drowned by the inroads of the sea. It was then also (A.D. 1110), that the lands of

* W. Humford, *Chron.*

Earl Godwin—those that now form the Godwin Sands—were engulphed, and separated from the main land. But in 1112, an extraordinary recess of the sea, in the English Channel, occurred, and continued for a whole year. This state of the elements was followed by great heat, and a drought so severe, that people waded across the Thames, between London Bridge and the Tower, on the 15th October, 1114. The Continent suffered as well, from this intense heat and drought; but this was succeeded, in the winter of 1115-16, by severe frosts, and by heavy falls of snow, the most heavy that "the oldest inhabitant alive had ever seen in England." This frost was so destructive to the fruits of the earth, in 1116, that, "there never was heard such in all this land, or in Wales." From 1117 to 1121, great storms, with heavy falls of rain, so injured the corn-crops, that, in 1122, there "was the greatest dearth of all in England." So many people perished with hunger, in 1124, that *dead bodies lay in the highways unburied.* Constant and heavy rains, in 1125, during the whole of the summer, together with severe storms, not only injured the crops, but were productive of floods and inundations, which, in their turn, spoiled the corn fields and meadows; broke up the bridges, destroyed towns, and drowned men.

The directly opposite state to this was experienced in 1135, for the drought was then so severe, on the Continent, that the Rhine was fordable in almost every part. Either as a consequence of this state of the air and of the earth, or from actual disease, there was another failure of the crops. This, added to the fatal murrain, that previously prevailed, caused a fearful and desolating famine, that continued for 12 years. "Then," says the *Anglo-Saxon Chronicle,* "was corn dear, and flesh, and cheese, and butter, for there was none in the land; wretched men starved with hunger: some lived on alms, who had been erewhile rich, and some fled the country." A hurricane, in February, 1144, was followed by a long drought in summer: there was no dew, and no rain fell until John the Baptist's day, 24th June. But in 1150, the rains were so heavy, and the standing corn so much damaged, that there was a dearth afterwards. The winter was severe, and the Thames so completely frozen, that men went over on foot and on horseback. On the other hand, in 1159, the heat and the drought were so great, that people were able to cross the Thames dry-shod. A severe thunder and hail storm, in 1171, which extended over France, England, Scotland, and Ireland, killed men, beasts, and birds. In the following year, says Matthew Paris, "on our Lord's nativity, thunders universal, unexpected, and dreadful, were heard in England, Ireland, and France." As a consequence, probably, of these great atmospherical aberrations, there was in this and the following years, "a great famine over the whole earth, such as had never been seen since the creation." * In 1176, great inundations, which occurred simultaneously in Holland and Lincolnshire, destroyed much cattle and many people. In the next year, there was a great drought in England, but, in 1178, or the year after that, destructive inundations occurred again. "The sea broke in," says Short, "on the marshes, and drowned people, villages, and castles innumerable." Severe thunderstorms were also experienced at this period. "The Castle of Loughbe (Lough Key, county Roscommon) was burned by fire from heaven, and six or seven score of distinguished persons destroyed: with 15 or 16 persons of kingly and chieftain descent. Such of them as were not burned, were drowned at the door of the house." (*Annals of*

* *Chronic. Conimbric.* España Sagrada, v. 22, p. 334.

Kilronan.) In the Annals of Ulster, the number killed by lightning is set down at 700. These vicissitudes were followed by a severe famine, in 1181, in England and Wales; and again in 1189. The same result occurred in Italy, in 1194, and in Spain in 1196.

Referring to the cosmical phenomena, that occurred during the same period, it is recorded, that concussions were felt in Italy in 1100, and again in 1104; in Palestine, France, and England, in 1105; in Italy, in 1107; in Lombardy and England (a part of the river Trent being dry for some hours), in 1110; in Germany, in 1112—when Rothenburg, on the Neckar, was overthrown; in Palestine, Italy, and Spain, in 1113; in Syria and Asia Minor, in 1116—many towns being destroyed; in northern Italy, Switzerland, southern Germany, and England, in 1117; violent ones in Italy, in 1118 and -19; also in England, and again in 1122 and -29; in Tyre, in 1127—many persons being swallowed up; in Switzerland and other places, in 1134 – the shocks lasting 40 days, with inundation of the sea in the Netherlands; in Sicily, in 1136,—the city of Catania, with 150,000 inhabitants, being swallowed up; in Syria, Mesopotamia, and Germany, in 1138—20 shocks, and accompanied by a thunderstorm; in France and England, in 1142; in Switzerland, Germany, and Portugal, in 1146; in Italy, in 1145; in Antioch, Damascus, Tripoli, Sicily—where 5,000 persons lost their lives; in Italy and France, in 1154 and -5; in Japan, in Syria—when 20,000 persons perished, and Antioch, Tripoli, and Damascus were ruined; in Sicily, London, and other parts of England, in 1159; in France, in 1163 and -5, also in England,—during which 12 miles of country were overflowed, destroying men, cattle, and houses; in Italy and Spain, in 1168 and -9; in Syria, the north of Africa, Sicily, Switzerland, Hungary, and Germany, in 1170; in Asia Minor, in 1172; and in England, in 1180—the cathedral at Lincoln, and many other buildings, being destroyed. This was followed by another shock, in 1185, shortly before Easter, which, says Short, "was the greatest earthquake over all England, that this nation ever felt." There were concussions in England in 1186, as, also, in Calabria, Sicily, and nearly the whole of Europe. They again occurred in 1199 in Constantinople, Poland, and England.

We may now continue the history of the diseases of this pestilential epoch, beginning at the point where we left off. As then mentioned, a fatal fever was prevailing in 1193 in England. At the same time, a disease, characterized by inflammation of the bowels, and temporary mania, and previously unknown, was prevailing in Portugal, together with plague and murrain in cattle. A pestilence also raged in Spain in 1212, and in the armies of the kings of Castile, Aragon, and Navarre; they were obliged, in consequence, to suspend operations, and to go into quarters. In 1217, the plague was so severe in Italy that barely a tenth part of the inhabitants, it is stated, remained alive. It committed great ravages, also, in the army of the Crusaders, then laying siege to Damietta; while, in the city itself, only 8 persons out of 70,000 are reported to have been left alive. An epizootic prevailed at the same time. It commenced in the East, and then spread through Hungary, Austria, Italy, France, and Germany, to England. Precisely the same route was observed with the murrain of 809-10. It commenced in Ireland in 1207; but did not appear in England until 10 years after.

In 1224, "a severe and mortal disease grew up," as stated in the Annals of the Four Masters, "in the whole country (Ireland), viz., a species of *Teascha*, through which towns were emptied, without leaving a single person in them; some recovered from the disease, but they were few." A few years later, or in 1227, Rome was visited by the plague; and still more severely in 1231. A deadly pestilence had broken out in Spain, the year before; and was particularly fatal to the Royal troops, at the capture of the island of Majorca. Villalba says: "It carried off, within a month, not only the poor and destitute, but nearly all the nobles, and left the island almost a desert." This was followed by an epidemic of erysipelas, which was so general, and of so severe a form, at this time, in Spain, that hospitals were erected specially for its treatment. The preceding writer gives the same description of this then terrible disease, termed, in Spain, *el fuego sacro, persico, ó herpes corrosivo,* as Sigebert, previously quoted. While these results were taking place in Spain, the plague, which had commenced two years previously in Egypt, appeared in Italy and France, and then spread to Denmark, the Scandinavian Provinces, and Russia.* Agues were *epidemic* in England in 1237; they were followed by the plague in 1239, and, in the next year, by a murrain; while the fish died on the English coast, and fowls perished in large numbers. Ireland was visited by the plague about the same time. It prevailed in France, in 1243; in England, in 1247, and again in 1252, and spread over the whole country. A murrain among cattle broke out in the last-named year, and was particularly prevalent in the fens; while, in 1254, there was "such a murrain of sheep, that, in many places, above half died." This epizootic was the rot, and it spread again, in 1275, over all England, and lasted 25 or 28 years, "till it left very few sheep alive." Short says, this was the *first rot* ever known in England. A disease, termed "the Evil of the Tongue," existed, at the same time, among horses, both in England and in France. We have few accounts of the plague at this period on the Continent, but it must have prevailed there to a considerable extent, as there were no less than seven visitations in Italy in this century.† Great numbers of the Crusaders perished in 1269 and -70, on their march to the Holy Land—among others, the French King Louis and his son. The plague also attacked the army of Philip, king of France, who entered Spain, in 1283, by Gerona, with 200,000 infantry and 18,000 horse,

* Broberg. On the *Plague at Stockholm.*

† See Table 2, Chapt. I., p. 79, Part I.

in order to seize the crown of Aragon: but disease, which so often effects more than the sword, carried off 40,000 men, and a large number of horses, and obliged him to abandon the enterprise. The plague was prevalent in Denmark, in 1282; epidemic dysentery in England, in 1285; and the plague in Spain, in 1296. It attacked the army of the King of Aragon, then besieging Mayorga,—a town of Castile—carrying off the Infante Don Pedro, many nobles, and a large number of soldiers. This closes the account of diseases for the 13th century.

Atmospherical phenomena. Heavy thunder and severe hailstorms occurred in 1201-2, "the hail as big as hen's eggs." Inundations followed, and then a severe frost, that continued until 12th April; so that the ground could neither be ploughed nor sown. A drought in Spain, in 1217, was so severe, that the pastures were burnt up, and the corn seed destroyed, after it had been sown. The misery was so great, from the failure of the crops, that people died in the squares, and at the corners of the streets. Horses, oxen, sheep, and even birds, perished from the same cause. In 1222, a severe thunderstorm in England destroyed several churches; while there was so much frost and snow in April, that the fruit blossoms perished. In the following year, hurricanes and hailstorms—the stones being square, and as large as hen's eggs—destroyed the corn, vines, and trees. Hence a dearth of corn, which then sold at 1*l.* 17*s.* 2*d.* the quarter—equivalent to about 25*l.* present currency—and an unparalleled famine, that was fatal to thousands. Heavy rains, accompanied by storms of thunder and lightning, which continued for thirteen days, in 1228, also destroyed nearly all the vegetation in England. In Friesland, 100,000 persons were drowned by an inundation; and the Tiber overflowed its banks, in 1231; thus adding to the misery produced, at that time, by the ravages of the plague in Rome. Severe frost, and heavy falls of snow, in England, in the winter of 1234-5, together with inclement and unseasonable weather, in the summer, caused so sore a famine, that 20,000 died of starvation in London alone. In 1339, "delicate mothers," says Short, "ate their own children." A severe drought, in 1252, which was accompanied by violent thunderstorms, again destroyed the vegetation, and hence a dearth: the same effect being produced in 1258, by the long continued and excessive rains of the previous years. The same failure of the crops occurred in France, so that "famine and death went hand in hand triumphantly together; people died so fast, that they digged great pits in churchyards, and filled them with heaps of dead." In London, 15,000 died from hunger alone. Famine was again prevalent in England and Scotland in 1262-66 and -71—that in Scotland, in 1266, having been caused by Palmer worms, which ate up all the vegetation. The year 1277 was memorable for the inundations, which destroyed thirty-three villages irrecoverably—the Dollert Sea, between Gronengean and East Friesland, being formed at the same time. In England, in 1282, there was, says Short, "from Christmas to Lady Day, such a frost and snow, as none then living had seen the like." In 1286, on the contrary, there was "an exceedingly hot summer; so that men died thereof." The year 1292 was marked by a grievous famine both in England and Scotland—the cattle being kept alive on straw alone. (Haile's *Annals.*)

Cosmical Phenomena. Commencing at the same date, the first event of this kind that we meet with is a concussion in England, in 1201—felt in York, and in the counties of Suffolk and Norfolk; also in Syria, Mesopotamia, and Palestine, in 1202; in Asia Minor, Cyprus, and Sicily, in 1204; in France, in 1207 and -8; in Antioch, Venice, and Bavaria, in 1212—the shocks being felt for six months; in France, in 1215; in England and Franche-Comte—where a mountain opened, and swallowed up 5,000 persons—in 1218; in Cyprus, the Tyrol, Germany, Italy, and Spain, in 1223; in Bohemia, Italy, and France, in 1231; in Syria, Candia, Naples, Piedmont, Savoy, and England, in 1246-48-49—when the church of St. Michael, on the Hill, London, was thrown down; and again in 1250, when a part of Winchester was destroyed, it is said by *the sea.* Concussions were felt in Japan, Poland, and Italy, in 1258; in Italy—60,000 persons being killed in Cilicia; in Piedmont and England, in 1275; in France, Germany, and Italy, in 1278, and again in 1282; in Italy and England, in 1285; *per universum orbem terrarum,* in 1286; and again in 1289; in Italy and Spain, in 1293; in Constantinople, in 1298; and in Germany and England, in 1299.

We have thus been brought to the commencement of another century, memorable by the appearance of what has been termed the "Black Death"; an erroneous term, as it leads to the conclusion, that it was a new disease; whereas it was only the re-appearance of the plague, in a more severe form, and to a greater extent, than before. It was not, in fact, until the epidemic reached the north of Europe, that it received the name of the Black Death—*Der schwarze Tod.* A murrain in Ireland, or "a great loss of cows (*Bo-dhith*), and a slaughter upon all beasts," ushered in this century. There was another murrain in Ireland in 1308; and an epizooty among horses in this island, in England, and in Italy, in 1313 and -15. In the last year, pestilence in the human race was prevalent, to a greater or less extent, in all parts of Europe, as, also, in Egypt. The true, or bubonic, plague broke out in Italy in 1311, and continued until 1316; spreading, in the meantime, to France and the north of Europe. Bergatus asserts, that it carried off a third of the inhabitants of these countries.* The mortality from a severe

* *Historia Universale.* Venet, 1570.

form of dysentery added to the ravages of the plague; and left few survivors, in 1316, to bury the dead. The plague re-appeared in England in 1319; in Sweden, in 1323, and continued in northern Europe until 1345. The earliest notice, it may be mentioned, that we have of influenza, in the British Isles, occurred at this period, or in 1325. Murrains prevailed at the same time. In 1321, there occurred a great destruction of cows throughout all Ireland, "the like of which was never known." The murrain continued its ravages the following year, and returned in 1324; attacking, in the latter year, oxen and kine of all kinds. In 1335, there was "a murrain of cattle, and a dearth of corn" in England; while, in 1338, the most part of the sheep in Ireland perished; being, according to the writers of the Census of Ireland, the first *ovine* epizooty that has been recorded in that island.

We have now arrived at a very important period in the history of diseases—the commencement of the pestilential epoch of the 14th century; characterized, as already remarked, by the sudden appearance of the Black Death, or the plague. The epidemic commenced in the east, and then slowly and gradually spread over Asia and Europe, by a route which has been previously detailed; having broken out at Cathay in China, in 1333, just 15 years before its appearance in Europe. Unfortunately, we have no very exact account of the circumstances, which attended the first outbreak of the malady, nor of the number of times the disease re-appeared, before it reached the confines of Europe. If, however, the statements, handed down to us by contemporary writers, are to be depended on, the irruptions of the disease in China must have been awful in the extreme, for we are assured, that 5,000,000 perished in one year.

The epidemic then passed, in a westerly direction, across the continent of Asia to the shores of the Black Sea; committing the same devastations, in the countries situated on this line of route, as in China. India was nearly depopulated, while Tartary, the Tartar kingdom of Kaptschak, Mesopotamia, Armenia, and Syria, were covered with dead bodies. Indeed, it was reported to Pope Clement, that, throughout the East, 23,000,000 were carried off; and this too independently of the mortality in China. The disease does not appear to have lost much of its intensity on reaching the confines of Asia; 22,000 people, and most of the animals, having been swept away in Gaza in six weeks. Cairo lost *daily*, when the plague was at its height, from 10,000 to 15,000; as many as, in modern times, great plagues have carried off during their whole course. Short remarks; "if it was so favourable as to leave a third part of men alive, in some few places, in others it took 15 out of 16; in more, it utterly extirpated the human race, as in Arthamusia." And Stow states, that many, who were whole (or well) in the morning, died before noon! *

From Constantinople the epidemic, still continuing its westerly course, appeared as early as 1347 in Cyprus, Sicily, some of the seaports in Italy, and Marseilles; the remaining islands of the Mediterranean, particularly Sardinia, Corsica, and Majorca, having been visited in succession. "Foci of contagion existed also in full activity along the whole southern coast of Europe; when, in January, 1348, the plague appeared in Avignon, and in other cities in the south of France and north of Italy, as well as in Spain."† Referring to the accounts transmitted to us of the intensity of the disease in this route, we find it recorded, that Cyprus, one of the first towns visited,

* *Summary of the History of England.*

† Hecker: *The Black Death of the 14th Century.*

was almost depopulated. Italy is said to have lost nearly half its inhabitants; and this account is rendered credible by the immense losses of individual cities and provinces. In Florence, there died, as we are told, 60,000; in Vienna, 100,000; and, in Avignon, the Pope was induced to consecrate the Rhone, so that bodies might be thrown into the river without delay, as the churchyards would no longer hold them. In Sardinia and Corsica, according to the account of the distinguished Florentine, John Villano, who was subsequently carried off by the plague, scarcely a third part of the population remained alive; and it is related of the Venetians, that they engaged ships, at a high rate, to retreat to the island,—so that after the plague had carried off three-fourths of the inhabitants, that proud city was left forlorn and desolate. From Avignon, the plague spread through France with the same virulence; in fact, it is stated that, in many places, not more than *two in twenty* of the inhabitants remained alive.* At Marseilles, 16,000 died in the short space of a month. Many were struck, as if by lightning, and died on the spot; and this more frequently among the young and strong than the old. Flight from infected cities seldom availed the fearful; for the germs of the disease, to use the language of the historians, adhered to them, and they fell sick, remote from assistance, in the solitude of their country houses. The Arabian and Spanish physicians speak with horror of this visitation, which continued five years in Spain. In 1350, the ravages of the plague were such that, according to Padre Sarmiénto, Spain had not suffered so much since the Deluge. Of three parts of the population, two perished. It was followed by acute fevers of scarcely less malignity.

The epidemic, at the end of 1348, appeared in England,

* Wood, *Historia et Antiquitates Universit. Oxon.*

and with the same fatality; for the sick, who were attacked with vomiting or spitting of blood, died, in some cases, immediately; in others, within twelve hours, or, at the latest, in two days.* It first broke out in the county of Dorset, and thence spread with unexampled rapidity through the counties of Devon and Somerset; after attacking Bristol and Gloucester, it reached Oxford, and, ultimately, London. The disease thus spread from south to north, the opposite course to that pursued by the epidemic cholera in England. From London the malady extended northwards; most of the large cities in this direction, as Norwich, Leicester, Yarmouth, and York, having suffered incredible losses. In Norwich, 51,000 are reported to have died, and, at the least, 100,000 in London; 50,000 corpses, arranged in layers, as we are informed by Barnes, being buried in large pits dug for the purpose. It is said that, in the whole country, scarcely a tenth part remained alive, although this visitation only lasted, in England, from Christmas, 1348, to the 29th September, 1349.† Still

* Barnes, *Hist. of Edward III.*, p. 432.

† It may be thought, that these accounts are much exaggerated; but we have witnessed nearly similar results in the present day, with the epidemic cholera, in certain situations. Thus, in Tiflis 1 in 3 of the inhabitants perished; and, in the province of the same name, 8 in 11. In Cairo, according to Clot Bey, 50,000 died out of a population of 150,000. In Arabia, also, 1 in 3 of the inhabitants died; in Mesopotamia 1 in 4; in Armenia 1 in 5; and in Persia 1 in 6. In Jamaica, in 1850, the mortality was as high in many places. At Port Maria, 600 died out of 900—400 being cut off in the space of ten days. But the rate was still higher in the small settlements, situated in the *hilly districts* and on calcareous soils! At Orange Cove, 75 were cut off, out of a population of 100. But at Bachelor's Hall, placed on a calcareous plateau, 400 or 500 feet above the level of the sea, 70 out of 73 of the residents died, although a medical man was residing on the adjoining estate at the time. In other instances, the cholera has been no less rapid than fatal, and hence the term, *cholera foudroyant*.

pursuing the same course, or northern direction, the plague next visited Scotland, where it committed the like devastations as in England—except in the mountainous districts of that country, which were scarcely at all affected. Hecker states, that Ireland was much less heavily visited than England, but this is an error: the epidemic would appear to have been as fatal in Ireland as in England, although it did not appear there until 1349. This was called the first great pestilence of this epoch; the second was in 1361; the third, about 1373; the fourth, in 1382; and the fifth, in 1391. Referring to this period, an Irish annalist, Friar Clyn, who was himself eventually carried off by the plague, observes: "The pestilence deprived of human inhabitants villages and cities, castles and towns; so that there was scarcely found a man to dwell therein." And he adds: "Scarcely one alone died in a house: commonly, husband, wife, children and servants, went the same way—the way of death."

From England the contagion, according to the language of the historical writers, was carried to Bergen, the capital of Norway; but, as we should say, from England, the morbific line next extended itself, by an invisible path, to the above-mentioned town. From this point it gradually spread, by its own peculiar and well-marked course, through this country, and thence to Poland and Russia; which it did not reach until two

At Punderpoor, in the East Indies, people were found tumbling over each other, in the public streets, as if struck by lightning: and in the Black Sea, during the Crimean war, men fell from the yard-arms, while reefing sails—so sudden was the attack! I, also, witnessed a similar outbreak on board the H.E.I.C. ship "Canning," while proceeding up the China Sea: men tumbling down suddenly, on deck, doubled up like a trussed fowl—the forearms on the arms; and the legs on the thighs. On the subsidence of the spasm, the ordinary symptoms of cholera set in.

years after its appearance in the south of France and in England. In Norway, the plague commenced, in its most frightful form, with vomiting of blood; and, throughout the whole country, spared not more than a third of the inhabitants. The sailors found no refuge in their ships, and vessels were often seen driving about on the ocean, or drifting on shore, whose crews had perished to the last man.* In Poland, the disease seems to have been equally severe, the inhabitants having died in such vast numbers, that scarcely a fourth part, it was calculated, remained alive. In Russia, also, the mortality was great; so that the same scenes of affliction and despair were exhibited here as occurred in those nations, which had already passed the ordeal. The same stupor and depression of spirits; the same horrible certainty of death; the same mode of burial. In Russia, too, the voice of nature was silenced by fear and horror; and, in the hour of danger, fathers and mothers deserted their children, and children their parents.† The same as in other epidemics, certain classes would appear to have been attacked more particularly than others. "It was observable, that though it was so general, yet neither Emperor, King, Prince, Lord, Governor, nor any Prime Magistrate of any nation, died of it. But as the clergy appeared to be the principal procurers of it by their licentiousness, so they, and the herd of the vulgar, deluded and drawn into practical atheism by their example, were the greatest sufferers. This scourge was foretold in the year 1316 or 17, by one *Robert*, a Jacobin Friar; that God would avenge the simony, sloth, luxury, lust, and covetousness, of the clergy shortly. And it as remarkably came to pass; for of the preaching brethren in Avignon,

* Torfæus, *Historia rerum Norvegicarum.*

† Richter, as quoted by Hecker

died 358; at Montpelier, out of 140, only 7 remained; and at Magdaley, 7 also were left of 140. At Marseilles, of 150 Minories, only 1 was left. . . . Of this plague, died 1,244,334* barefooted monks, and, of Carthusian monks, died 124,434." † And so on of all the rest of the clergy.

Disease in the brute creation walked hand in hand with that in the human race. In England, 5,000 sheep are reported to have died in one pasture alone, in 1348. Cattle, and all other animals, were attacked at the same time. "They died," says Short, "in holes, furrows, and ditches, in innumerable multitudes over the whole kingdom." The disease among the cattle continued during the following year, not only in England but in Wales, "which," according to one authority, "was the origin (with Welsh graziers) of taking gold in payment for cattle from Englishmen."—(*Iolo.* Welsh MS.) The feathered race, together with the fish in the sea, suffered at the same time, and, apparently, to the same extent: some authors stating even, that the fowls and fishes had blotches, or carbuncles, on them.

What was termed "the second great Plague," being the second in the reign of Edward 3rd, commenced in France, England, and Ireland, in 1361, and continued for nearly ten years. In this visitation, the disease raged with the greatest violence in mountainous districts, which were spared in 1348; and it attacked the nobility and gentry instead of the poor, as in the former visitation. The epidemic was accompanied by small-pox, and a fatal murrain. Milan, which had escaped in 1348, was attacked this year with the plague: it broke out also in

* There must be an error here, as regards the number: probably a printer's error.

† *Chron. Belgic* and *Spangenb* quoted by Short.

Sweden. This second mortality, to distinguish it from that of 1350, in which King Alfonso died, commenced in Spain in 1363. The 3rd pestilence, according to Otterbourne, began in England in 1368, but, according to Short, not until 1370. "This 3rd mortality," he says, "was very great both of men and cattle, the like seldom heard of." It was prevalent in Wales and in Ireland in the latter year, as, also, in Scotland, but was here termed the 2nd pestilence—the first having been in 1349. The next visitation, the 4th, was in 1374, in England: but Italy was spared until 1380, and France, until the following year. From Avignon, the plague spread through the country, depopulating several towns. It raged for four or five years, in France, also in Germany, Italy, Greece, etc. The 5th pestilence commenced in 1391, causing a great mortality over all England, and especially in Norfolk and Yorkshire; 11,000 having died in the city of York. The mortality however was partly due to dysentery, which prevailed at the same time as the plague. In 1399, the mortality in England was so great, that "the king suspended the law, which restrained widows from marrying within a year after the death of their husbands." The plague was also raging at this time in Germany and in Italy, or Lombardy, being the last recorded visitation of this scourge in the 14th century.

Physical diseases, however, were not the only evils with which this generation was afflicted; there were mental ones also. In 1260, a class of monomaniacs, called the Flagellants, appeared in Italy, as *Devoti;* under the vain delusion that, by flagellation, they could make their bodies pay for the sins of their souls—the innocent for the guilty. Hence "when the land was polluted by vices and crimes,"*

* Words of *Monachus Paduanus*, quoted in *Förstemanns Treatise*, which is the best on the subject.

a spirit of remorse suddenly seized the minds of the Italians. "Noble and ignoble, old and young, and even children of five years of age, marched through the streets with no covering but a scarf round the waist. They each carried a scourge of leathern thongs, which they applied to their limbs, amid sighs and tears, with such violence, that the blood flowed from the wounds; not only during the day, but even by night, and in the severest weather, they traversed the cities with burning torches and banners, in thousands and tens of thousands, headed by their priests, and prostrated themselves before the altars." * This monomania originated, according to Schnurrer, with Regnier, a hermit of Perugia, and a fanatic preacher of penitence.† From Italy, these processions of the Flagellants extended to southern Germany, and even farther—to Saxony, Bohemia, and Poland. There was a great procession of the Flagellants at Strasbourg, in 1296; after which this outbreak of religious monomania appeared to have subsided. But in 1334, a sermon of Venturinus, a Dominican Friar, of Bergamo, induced 10,000 persons to undertake a new pilgrimage. Like the former mania, it extended to Germany, 200 Flagellants having entered Strasbourg, in 1349, where they were received with joy, and hospitably entertained by the citizens. Above a thousand joined the brotherhood, which now assumed the appearance of a wandering tribe, and separated into two bodies—one journeying to the north and the other to the south. At Spiers, all the inhabitants of the town were carried away by the illusion: they conducted the strangers to their houses, and regaled them for the night.‡ It was not merely some individual parts of the country that

* Hecker, *The Epidemics of the Middle Ages.*

† *Chronicle of the Plagues*, t. i., p. 291.

‡ They never remained longer than one night in one place.

fostered them; all Germany, Hungary, Poland, Bohemia, Silesia and Flanders were carried away by the illusion.

The acts and proceedings of the Flagellants of the 13th and the 14th centuries were precisely the same. The Brothers of the Cross were not permitted to seek for free quarters, or even to enter a house without being invited; they were forbidden to converse with females; and if they transgressed these rules, they were sentenced by the Superior to receive so many lashes by way of penance. Eccleisastics had not, as such, any pre-eminence among them. Penance was performed, twice a day, in public; and when they arrived at the place of flagellation, they stripped to the waist, keeping on only a linen garment, that reached to the ankles. They then lay down in a large circle, in different positions, according to the nature of their crimes—the adulterer with his face to the ground; the perjurer on his side, etc., etc.—and were then castigated, some more and some less, by the master. They then rose, scourged themselves, amid the singing of psalms, and supplications for averting the plague, with genuflexions and other ceremonies, of which contemporary writers give various accounts. "One of them, in conclusion, stood up to read a letter, which it was pretended an angel had brought from heaven, to St. Peter's Church at Jerusalem, stating that Christ, who was sore displeased at the sins of man, had granted, at the intercession of the holy Virgin and of the angels, that all, who should wander about for thirty-four days and scourge themselves, should be partakers of the Divine grace." (Hecker, *loc. cit.* p. 38.) If asked who had sealed the letter, the bold reply was, the same who had sealed the Gospel! *

* How deeply this mania had impressed the minds of those suffering from it, is shown by the deposition of a citizen of Nordhausen, that his wife, in the belief of performing a Christian act,

It was announced by the Brotherhood, that the pilgrimage of the Flagellants was to continue for a space of thirty-four years; but a re-action set in long before the end of that term. As early as the first year of their establishment, the general indignation set bounds to their intrigues. The Sorbonne at Paris and the Emperor Charles applied to the Pope, Clement, for assistance against these formidable bodies, which had well nigh destroyed the influence of the clergy, in every place; for the Flagellants gained more credit than the Priests, from whom they entirely withdrew themselves, after a time. They were also regarded with no less suspicion and dread by the secular power, more particularly as their sanctity came to be questioned. "The Pope, regardless of the intercession of several cardinals, interdicted their public penances, which he had not authorized; and, on pain of excommunication, prohibited throughout Christendom, the continuance of these pilgrimages. Philip VI., supported by the condemnatory judgment of the Sorbonne, forbad their reception in France. Manfred, King of Sicily, at the same time, threatened them with the punishment of death; and, in the East, they were withstood by several bishops, among whom was Janussius, of Gnesen, and Preczlau, of Breslau, who condemned to death one of their masters, formerly a deacon; and, in conformity with the barbarity of the times, had him publicly burnt. In Westphalia, where, so shortly before, they had venerated the Brothers of the Cross, they now persecuted them with relentless severity; and in the Mark, as well as in all the other countries of Germany, they pursued them, as if they had been the authors of every misfortune." * The Flagellants of the 14th century

wanted to scourge her children, *as soon as they were baptized!*—(Hecker, *loc. cit.* p. 37.)

* Hecker, *loc. cit.* p. 39.

were not the last; the same fanaticism manifested itself in the next century, and it was deemed necessary to extirpate them with fire and sword, in several parts of Germany. Processions of the Cross-bearers were also seen in Italy as late as 1710.

In 1341, the "Barking Disease," or Lycanthropia (λυκος, a wolf, and *ανθρωπος*, a man), appeared in Ireland. In this singular affection, or wolf madness, men are seen running about in the fields and graveyards—sometimes on all fours—howling like wolves, which they fancy themselves to be. The disease remains, with some, for two or three weeks; with others, for a month, and occasionally for one or two years. It would seem to have prevailed, at the same time, in England, as Otterbourne states, that "a most terrible epidemic madness raged this year (1355) in England, affecting most of the people."* And Camden remarks; "Men and women, old and young, *throughout the whole country*, barked like dogs, and the children like whelps." † ‡ What was termed the "King's Game," supposed to have been the "Dancing Mania," broke out in Ireland, in 1361; and epidemic madness prevailed in England in 1373. Short concludes, that it was the same disease; but does not give any authority for the statement. Be this as it may, this singular malady appeared in Germany, where it was called St. John's dance, in an epidemic form, the following year, commencing at Aix-la-Chapelle. Men and women, possessed of the same delusion, formed circles in the street; and appearing to have lost all control over themselves, continued to dance, regardless of the bystanders, for hours together,

* *Rerum Anglicanum.* † *Annals.*

‡ The last epidemic visitation of this disease, in the British Isles, was in 1700. Isolated cases, however, have been observed since.

until they fell down to the ground in a state of exhaustion. Although appearing to be, during the paroxysm, insensible to all external objects, their diseased imaginations called up visions and spirits, to whom they appealed, and whose names they called out. From Aix-la-Chapelle, the disease spread to the Netherlands, Belgium, Cologne, and other parts of Germany. At Metz, the streets were filled with no less than 1,100 dancers at one time. In 1418, it broke out at Strasbourg, but was here called the dance of St. Vitus, and for these reasons. In order to arrest the plague, as it was termed in Germany—*St. Vits-tanz ward gennant die Plag*—those attacked were taken to the chapel of St. Vitus, and induced to make offerings and prayers to the Saint for their recovery.* Afterwards, the disease itself was called by the name of the Saint, whose intercession was sought to put it away. The former name, that of St. John, originated in the circumstance, that the first manifestations of the disease occurred on St. John's day; which, at that time, was solemnized by half-heathen, half-Christian customs. One of these was the *Nodfyr*, an ancient heathen custom, from a belief that persons, who passed through the flames of this fire, would be preserved, for the whole year, from fevers and other diseases. Although supposed to be so, this was not the first visitation of the dancing mania in Germany; children, to the number of a hundred, were suddenly seized at Erfurt, in 1237, with the same disease; and 200 fanatics are said to have mani-

* St. Vitus was a Sicilian youth, supposed to have suffered martyrdom in the year 303, under Diocletian. His body, *or one that was stated to be his*, was taken, 500 *years after*, or in 836, to Corvey; and he became one of the fourteen Saintly Helpers (Nothelfer ar Apotheker) of Germany. The latter term is supposed by Hecker to be a corruption of Apotropœi, the *dii averrunci* of the heathens—those that put away evil!

fested the same propensity at Utrecht, in 1278. In fact it will almost invariably be found, on inquiry, that all general epidemics have been preceded by isolated cases, or by isolated outbreaks. The disease continued to prevail until the end of the fifteenth century; and the feeling with which it was regarded, may be surmised by a popular malediction, long in use in Germany—*Das dich Sanct Vits-tanz ankomme*—May St. Vitus' dance seize you. Latterly, it assumed a milder form, affecting individuals only, not numbers. It became, in fact, endemic instead of being epidemic. As a singular circumstance, it may be mentioned, that the same disease prevailed in Abyssinia in the 19th century; and that those attacked sought the aid of St. John and other saints.*

About the same time, or in the middle of the 14th century, appeared another disease, allied to the former, but differing from it in several respects. This is what has been termed *Tarantism,* from *tarantula* a ground spider; on the supposition that this insect was the cause of the disease. This is an error, as the symptoms produced from the bite of the Tarantula are different to those observed with persons suffering from Tarantism.† The symptoms of Tarantism are, at first, melancholia and stupor: the patient breathes with difficulty, the pulse grows feeble, and all sense and motion are lost. In this state he will remain until roused by music: he then springs up, shouts for joy, and dances without intermis-

* See *Life and Adventures of Nathaniel Pearce, in Abyssinia, from* 1810 *to* 1819. London, 1831.

† Dr. Cerillo, Professor of Natural History, at Naples, contradicts all the stories of the effects produced by the bite of the Tarantula. He says, that experiments have been tried with the Tarantula; and that neither men nor animals have experienced any ill-effect from the bite, excepting a trifling inflammation of the part bitten.

sion, until he sinks down, exhausted with his efforts. This was found to be the only means by which a patient could be roused from this state of stupor. Mathioli states, that however hopeless a patient appeared to be, while lying stretched on the bed of sickness; no sooner did he hear the sound of the music than he would spring up, as if inspired with new life, and continue to dance, without apparent fatigue, for hours. If, however, the music ceased suddenly, the patient would fall powerless to the ground; and lie there, in an apparently senseless state, until roused again by the same inspiring sound.* Hence it was necessary to have a succession of musicians, until the dancer left off of his own accord, or from a feeling of exhaustion. So common was the disease, and so regular the employment of this non-medical remedy—the most agreeable, perhaps, of any hitherto proposed—that bands of musicians traversed Italy, during the summer season, with the express object of dispossessing the possessed of their malady, and others of their money. Their arrival in a particular town was always the occasion of a grand *fête;* and people were in the habit of laying by money, in order to reward the welcome visitors. These *fêtes* were called "the ladies' little carnival"—*il carnevaletto delle donne*—the ladies being the chief promoters of these medical carnivals.†

That this was a true mental epidemic, and not caused by so local and particular a cause as the bite of an insect, may be inferred from the variations that the disease presented, and from the analogy of the symptoms with the dance of St. Vitus. Thus, both classes had a predilection

* *Commentarii in Dioscorid.* Venet, 1565, Lib. 2, ch. 57.

† It is stated by Ferdinando, that one Lady (Mita Lupa) expended her whole fortune in this way. (*Centum historiæ seu observationes et casus medici.* Venet, 1621.)

for certain colours, an abhorrence of others, although their predilections were different. Some fancied yellow, others black; and they flew into a great rage at the sight of colours they disliked. The St. Vitus' dancers detested red colours, but the Tarantulists preferred them. Another peculiarity of these Italian and German monomaniacs was a predilection for water, into which they would sometimes throw themselves; some showed their fondness for water—the very opposite state to that of hydrophobia—by carrying vessels of water in their hands, while dancing; others preferred to dance in the midst of vessels filled with water, or in a situation surrounded by water. As the effects in both diseases are thus nearly identical, they must have been produced by the same cause; and as the Tarantula does not exist in Germany, it could not have been the cause of St. Vitus' dance, nor, consequently, of Tarantism.* This last-named disease continued to prevail until the end of the 17th century, after which only isolated cases occurred.

As regards the atmospherical phenomena, that were observed during the above period, or, in the 14th century, a great drought is mentioned as having occurred in Spain, in 1302: so that the ground remained unploughed on account of the dryness. To this succeeded, in the following year, heavy and long continued rains. In 1313-14 blight produced a failure of the crops, and of all the fruits of the earth. In England, the deficiency was so great, and food so scarce, that even the King's family found it difficult, at times, to procure bread. Wheat sold, in 1316, for 45sh. the quarter—equivalent to 33*l.* at the present time. In Scotland, the price of wheat, at one

* For more copious details of these two diseases, see a work on the subject—*Die Tanzwuth, eine Volkskrankheit im Mittelalter,*—by Dr. Hecker, Berlin, 1832.

period, was 5*l.* the quarter—equivalent to 75*l.* present currency.* Horseflesh was a luxury, and all other food so scarce, that men and children were killed and eaten; and prisoners in the jails, says Walsingham, tore new-comers to pieces, and eat them on the spot. The famine was equally severe in Ireland, but this lamentable state of things was put a stop to, in 1318, by an abundant harvest. The year 1323 was remarkable for the intense cold, the North Sea, according to Short, having been frozen over *from England to Norway.* But, in 1325-6, the seasons were so warm, that the rivers in England were dried up, and both wild and tame animals perished from thirst. In 1327, on the other hand, the season was as wet; while, in 1330, the harvest was so late, on account of heavy rains, that the wheat was not housed before November 21st, or peas before the 30th. A scarcity followed, and many died from hunger. Turning to the East, we find that, simultaneously with the outbreak of the plague in China, a parching drought prevailed in the tract of country watered by the rivers Keang and Hoai. This was followed by such violent torrents of rain in and about Kingsai, at this period the capital of the empire, that, according to tradition, more than 400,000 people perished in the floods. In the succeeding year, an unexampled drought was felt in Tche; and in Kou-Kouang and Ho-man a drought prevailed, accompanied by innumerable swarms of locusts, while famine and pestilence, as usual, followed in their train. From this time, there was a constant succession of rains and floods in China; and in the

* In order to show, how exorbitant these prices were, and how great the scarcity must have been, it is only necessary to add, that, in 1338, a quarter of wheat cost only 40 pence; a quarter of barley 10 pence; and oats the same. The price of a fat ox was, then, 6 shillings; and that of a sheep only sixpence.

year 1338, after three months' rain in Pien-tcheou and Leang-tcheou, there followed unheard-of inundations, which destroyed seven cities. Violent rains, with floods and inundations, continued to recur, and to devastate various districts, until 1347; when, as we are informed, the fury of the elements subsided in China. We have no account of the prevalence of these abnormal effects in the other countries of Asia or in Asia Minor; but that they occurred, the same as in China and in Europe, there can be no doubt. In Ireland, in 1336, there was, what is termed, "a great plague of snow and frost, from the first fortnight of winter until a part of the spring had commenced;" the fall of snow being so heavy, that "a great portion of the cattle of Erin was lost by it, and the grass and cornfields were destroyed." The next particulars of which we have any precise account, are the floods, that occurred in the vicinity of the Rhine, and in France, in 1338, effects which could not be attributed, says Dr. Hecker, to rain alone; for everywhere, even on the tops of mountains, springs were seen to burst forth, and dry tracts were laid under water, in an inexplicable manner. The order of the seasons, also, continues this writer, seemed to be inverted: rains, floods, and failures in the crops, were so general, that few places were exempt from them. The consequence of failure in the crops was soon felt, especially in Italy and the surrounding countries, where, in one particular year, a rain, which continued for five months, had destroyed the seed. In the larger cities they were compelled, in the spring of 1347, to have recourse to a distribution of bread among the poor, particularly at Florence; large bake-houses being erected, from which 94,000 loaves of bread, of 12 ounces each, were dispensed daily. The same inversion of the seasons, and the same results, famine, were felt more or less in all the countries of Europe, although not to the same extent; so that, as one writer expresses himself, "children died of want in their mothers' arms; and want, misery, and despair, were general throughout Christendom." * Short observes that, in 1347, the year before the plague commenced in England, "it rained from Christmas to Midsummer, without one day's interval," or cessation. The weather, the next year, would appear to have been fine, for Archbishop Parker remarks: "Immediately after the feast of our Lord's nativity, in winter, and amidst the greatest *abundance of provisions;* when there could be no suspicion, that a contagious disease would arise among men, the plague commenced." (*Antiq. Brit.*, p. 360.)

Other atmospherical phenomena were observed during this epidemic period, for great and extraordinary meteors appeared in many places, and were regarded with superstitious horror. A pillar of fire, which, on the 20th December, 1348, remained for an hour at sunrise over the Pope's palace in Avignon; a fireball, which, in the same year, was seen at sunset over Paris, and was distinguished from similar phenomena by its longer duration, are also recorded in the chronicles of the age.

The cosmical phenomena that occurred, during the above period, were as follows. Earthquakes in Asia Minor, Alexandria, Italy, and Poland, in 1302-4; in France, in 1316; in Germany and England, in 1320; in Switzerland, Italy, and Germany (a severe one), in 1322; in Bohemia, in 1326; in England and in Italy—5,000 persons being killed in Norcia—in 1328; in Germany, in 1329; in Italy, in 1331; in Constantinople and Thuringia—together with great atmospherical disturbances—in 1332; and in Italy, in 1333. In the same year, or a few months after the outbreak of the plague in China, commenced a series of terrestrial commotions, almost unexampled in the history of such phenomena; for so severe an earthquake occurred, at and near Kingsai, that the mountains of Ki-ming-chan fell in, and a lake

* Muratori. Tom. 2, p. 524.

was formed of more than a hundred leagues in circumference, where thousands found their grave. These concussions continued to return in China, at short intervals, for many years: a severe earthquake, which lasted, with certain intervals, ten days, having occurred in Kingsai in 1338, and again in 1339, when the mountain Hou-tchang was swallowed up. From this time, they became more and more frequent until 1347, when they ceased for the moment, or for a longer or shorter period. Turning again to the West, we find, that a severe concussion occurred at Tripoli, in Syria, and in Italy, in 1339: in Syria, Turkey, and Egypt, in 1334; while in 1347, soon after the plague had broken out in the island of Cyprus, an earthquake, accompanied by a frightful hurricane, shook the foundations of the island. The sea overflowed, the ships were dashed to pieces on the rocks; and few outlived the terrific event, whereby, according to the writers of that period, this fertile and blooming island was converted into a desert.* Pursuing the course of these grand revolutions further, to quote the language of Dr. Hecker, we find notice of an unexampled earthquake, which, on the 25th January, 1348, shook Greece, Italy, and the neighbouring countries—Naples, Rome, Pisa, Bologna, Padua, Venice, and many other cities having suffered very severely; whole villages in the surrounding districts were swallowed up; castles, houses, and churches, were overthrown, and thousands of persons buried in their ruins. In Corinthia, more than thirty villages, together with all the churches, were demolished, and more than a thousand corpses were drawn out of the rubbish; while the city of Villach was so completely destroyed, that a few only of its numerous inhabitants escaped. Not only were cities destroyed, or left in ruins, and whole villages swallowed up, but it was also found, when the earth ceased to tremble, that mountains even had been removed from their position. The same effects were experienced, although to a less extent, in France, England, Germany, Denmark, Sweden, and much farther north: as, in consequence of the violent concussions, towering icebergs formed, we are told, on the coast of East Greenland, so that no one, since that period, has been able to penetrate beyond that shore. Mezeray, speaking of these phenomena, says, "A universal concussion of the earth, both in France and the countries to the north, overturned whole towns, rooted up trees and mountains, and filled the plains with chasms so profound, that it appeared as if hell was about to swallow up

* Deguignes, *op. cit.*, p. 225.

the whole human race." These destructive earthquakes were again felt in Italy, and nearly all other parts of Europe, in 1349; in Turkey, Italy, and France, in 1353-4; in Switzerland, Bavaria, Germany, Spain, and Portugal, in 1356; in Swabia, Switzerland, and Spain, in 1357; in Italy, in 1361-7; in Germany, Denmark, Sweden, and the other countries to the north, in 1368; from which date they became less frequent and less violent, but continued to recur, in all the countries and localities previously affected, until the end of the century.

"Such are the events," says Hecker, "which took place at the time of the irruption of the black death. Contemporaries have explained them after their own manner, and have thus, like their posterity under similar circumstances, given a proof, that mortals possess neither senses nor intellectual powers sufficiently acute to comprehend the phenomena produced by the earth's organism: much less scientifically to understand their effects. To attempt, five centuries after that age of desolation, to point out the causes of a cosmical commotion, which has never recurred to an equal extent; to indicate scientifically the influences which called forth so terrific a poison in the bodies of men and animals, *exceeds the limits of human understanding*. If we are even now unable, with all the varied resources of an extended knowledge of nature, to define that condition of the atmosphere, by which pestilences are generated, still less can we pretend to reason retrospectively from the 19th to the 14th century; but, if we take a general view of the occurrences, that century will give us copious information, and, as applicable to all succeeding times, of high importance.*

Having thus narrated the principal events connected with this remarkable irruption of plague, we may now continue the history of this disease, and of those by which it was accompanied. According to Otterbourne, there was a

* *The Black Death of the 14th Century.*

great mortality of people in England in 1400 and -1; and, according to another authority, in Scotland, from what was there termed the fourth pestilence, or visitation of plague, and said to be more calamitous than either of the previous ones.* So, also, in 1404-6, there was "a great plague on men's bodies in city and country; many whole families died, and, in London, 30,000 died of it."—(*Short.*) Plague, small-pox, leprosy, and murrain, were all prevailing in Ireland, in 1407, and plague in Wales; where it was ascribed to putrid fish, that had been cast ashore—a proof that the finny race was affected at the same time. The plague, which, in 1394, had carried off 12,000 persons in Valencia, re-appeared in Barcelona in 1408, and again in 1410; as, also, in Seville and Gibraltar. It broke out again in Spain, in 1415, and continued, according to Valeriolus, for 15 years. A pestilence prevailed in Denmark, in 1413, in which year Henry IV. of England died, having previously suffered both from epilepsy and leprosy. "A frightful dysentery," which raged at this time in France, caused great losses among the English troops from 1415 to 1421—at the siege of Harfleur, after the battle of Agincourt, and, again, at the siege of Meaux. In the last named year, the plague invaded Sweden and England, and Ireland, from 1425 to -30. Mortimer, Earl of March, and Regent of England, died of it in Meath. King Edward, who had shut himself up in a monastery, in order to avoid the disease, caught the infection, nevertheless, and died! Dysentery carried off great numbers in Scotland, about 1439; and soon after, "the pestilence without mercy" threatened to depopulate the country. In 1440, an epidemic constitution set in, which affected most of the countries in Europe with

* *De Orygynale Chronykil of Scotland.* By Andrew of Wyntown. With Notes by David Macpherson. 1795.

several diseases—especially influenza, small-pox, epidemic pneumonia, and dysentery. "A most tragical time," says Short, "of great destruction." The plague broke out in Sweden in 1439 and -40, and, in 1445, an epidemic prevailed in England, "whereof," says the above writer, "people dropt down, as they walked along the streets, without either fever, or other previous symptom." In 1449, plague raged in Italy, and continued its devastations for some years; 60,000 persons having died of it in Milan alone.

Another progressive plague was observed in 1450, having commenced in Asia, and having thence spread to Italy, France, Germany, etc. It re-appeared in England, in 1464, and, also, in Sweden; and was very destructive in both countries. In 1466, a fatal plague (*pestilentia magna*) prevailed in Dublin, Meath, and Leinster; and, in the same year, in Spain; during which the city of Cadiz was nearly depopulated. The plague re-appeared in Spain, in 1475-6; and, two years after, on the Continent of Europe, and in England. In Paris, 40,000 died, and multitudes, says Short, died of it in London, and other parts of England, during the 14 months that it continued. It broke out again in Ireland, Denmark, and Italy, in 1484, during which 137,000 died in Milan alone. Another visitation of plague, in 1489, "was so devastating, that the people did not bury the dead throughout Ireland." (*Annals of the Four Masters.*) During this period, malignant fevers raged in all places—in Italy, Switzerland, France, Germany, Spain, and England. These intercurrent diseases, as they are termed, are sometimes not only more general and more continuous than the chief epidemic, but they are frequently more fatal. Fracastero states, that during the visitation of plague in Italy, at the period just mentioned, viz., from 1477 to 1485, 20,000 persons died in Brixen, and 30,000 in Vienna, from other diseases than the plague. A malignant fever, which commenced in France, Germany, etc. in 1480, continued for two years; and then returned, in 1486, with great virulence. Petechial fever, another and peculiar form of fever, was also the invariable accompaniment of the plague in Europe, at this and subsequent periods. When it first made its appearance is uncertain; but it was not known in Spain until 1488 or 1490. It was first observed in Granada, in the army of Ferdinand, the Catholic, which it almost annihilated; making, at the same time, great havoc among the opposing hosts—the Moors.* A different form of disease, supposed to have been previously unknown—viz., Lues venerea—made its appearance at Naples in 1493. As this was shortly after the arrival of the Spanish Fleet from America, it has been inferred, that they brought the disease with them. But Pintor, physician to Pope Alexander VI., who published a work in March, 1493, previously to the arrival of the Fleet, describes this affection among others. Villalba also states, that a work was written, in 1489, by Pedro Martir de Angleria, in which he describes a disease that is evidently *lues venerea*. The same, or a similar, disease is supposed, as before mentioned, to have existed in Ireland A.D. 949. Besides, the disease, at this period, prevailed epidemically, and affected *all classes*; the cause, therefore, must have been general, not individual. According to the description given of lues venerea by Pintor and other writers, this disease, at first, assumed the form of fever, and was supposed to be communicated in the same way as other fevers. It was referred to the malign influence of the stars, atmospherical changes, inundations, etc. As such, no shame was attached to those who were afflicted with it.

* Villalba. T. 1, pp. 69 and 99.

Another, and more interesting, disease appeared in 1485,—the *Sudor Anglicanus,* or sweating sickness, which broke out in England, this year. It was a violent fever, ushered in by a slight rigor; attended with a great internal heat, intolerable thirst, great prostration of the vital powers, oppression at the stomach, headache and stupor. This was followed by a profuse, fetid, perspiration over the whole body, and a rapid death—for "all, as soon as the sweat took them, or within a short time after, yielded up the ghost. Scarce one amongst an hundred, that sickened, did escape with life."* † It commenced at Shrewsbury the beginning of August, but did not break out in London until the end of the month. Two Lord Mayors and six Aldermen died within a week; and so rapid was the disease, that men, who had been in perfect health in the evening, were numbered among the dead in the morning. The disease spread from east to west, and, by the end of the year, had visited almost every place in the kingdom. During this short period, a considerable proportion of the population fell victims to this new epidemic, which attacked principally the strong and the robust. Medicine appeared to be of *no* avail. Although thus general in England, the epidemic, at this time, did not spread to Scotland, Ireland, Calais,—then occupied by the English—or to the Continent. The next visitation of this disease,

* This disease, although evidently produced by the same cause as the plague, would appear to have more analogy to the epidemic cholera than to the former disease. Thus Kaye, who has given the best account of it, states, that the patient had a *whining, sighing* voice (*vox colerica*) : great restlessness, (*jactitation*), and, in the severe cases, spasms of the extremities. Vomiting and purging were also present in some cases.

† Holingshed. Vol. 3, p. 482.

in 1506, was a mild one, and occasioned few deaths. Like the former, it did not extend either to Scotland or to the Continent, but appeared in Ireland. But although this disease did not spread to the Continent, the petechial fever made its appearance in Italy, according to Fracastero, for the first time.

The third visitation of the "sweating sickness," which occurred in 1517, was more severe than either of the others. It broke out in London, in July, and was so rapid in its course, that those attacked were carried off in two or three hours; while so few recovered, that the first shivering fit was regarded as the harbinger of death. Lords Grey and Clinton succumbed to it, as well as many knights and persons about the Court. From London, the epidemic spread gradually over England, where it raged as severely as in the capital. In Oxford and Cambridge, many men of science and of note were victims to this new form of disease. In some towns, a third, and, in others, half the inhabitants were carried off. It prevailed, at the same time, in Ireland, being the second visitation of the disease in that island; and appears to have been as fatal as in England, carrying off the Lord Chancellor, the Archbishop of Dublin, and many other noted persons. Scotland and the Continent again escaped, with the exception of Calais, where, however, only the English were attacked. In 1528, the "sweating sickness" again broke out in London, and then spread over the whole kingdom. It was more general, and more fatal, than in either of the other visitations; hence, it was called "the great mortality."

The disease had entirely ceased in England—in fact, it does not appear to have continued more than a few weeks in any one place—when it broke out in Hamburg, on the 25th July, 1529. Within the space of twenty-two days, it carried off 1,100 persons; altogether about 2,000 died in this city. The epidemic next appeared in Lübeck on the 30th July, and was productive of the same destruction of life as in Hamburg. It was also remarked here as elsewhere, that young and robust persons of the better class were more liable to be attacked than children and poor people, living in cellars, garrets, and other confined places. In the following August, the disease broke out almost simultaneously at Stettin, Dantzig, and other towns—at Cologne, Gottingen, Hanover, Frankfort on the Maine, Strasbourg, and Augsburg, on the other side of the Danube. But there was no regular progression of the disease on this occasion. For instance, it commenced, on the 24th August, at Strasbourg—a long distance from Hamburg and Lübeck; at Stettin, on the 31st August; at Dantzig, on the 1st September; at Augsburg, on the 6th; and at Cologne, on the 7th September—the two extremities of the inflicted region being thus attacked almost simultaneously. While this occurred in Germany, the inhabitants of Denmark, Norway, Sweden, and other northern countries were likewise visited by this destructive epidemic. "It was," as Hecker has remarked, "like a violent conflagration, which spread in all directions." The flames, however, did not issue from one focus, but rose up, spontaneously, everywhere, as if self-ignited. That this disease arose spontaneously, and that it was not propagated by contagion, may also be inferred from its short duration in the different towns visited. Although several thousands were attacked in Stettin, the epidemic only lasted a week. At Dantzig, where 3,000 persons are said to have been carried off, it subsided in *five* days! The Netherlands were also invaded; and it is a remarkable circumstance, that the epidemic did not appear in this country—

although situated between England and Lübeck—until four weeks after it had commenced in the latter town.

In 1551, after an interval of twenty-three years, the "sweating sickness" appeared again in England, having been preceded by fogs of a bad odour. It commenced at Shrewsbury, and the irruption was so sudden and so general, that every house became an hospital. The old and the very young alone remained exempt. Seclusion was useless: people were attacked at all times, and under all circumstances; while its fatality was such, that patients were carried off in the course of a few hours—some even in one! Within a few days, 960 of the inhabitants of this city were cut off—the majority being in the prime of life. From Shrewsbury, the epidemic spread over the whole of England, as far as the borders of Scotland, but not beyond. It prevailed from the middle of April to the end of September; having commenced in London in July, and having been accompanied, during the whole of its progress, by thick, stinking mists. This visitation was a very severe one: no rank was spared, its victims being taken alike from the palaces of the nobles, and the huts of the poor. Among the former, were the Duke of Suffolk and his brother. It was remarked, during this visitation, that Frenchmen, in England, escaped; and that Englishmen residing abroad were alike attacked, while the natives escaped. The Scotch and the Irish were also exempt. But, in the first invasion of the disease in England, foreigners were attacked, and even before the English. A slight visitation of the disease was observed in London in 1741; but no regular outbreak has been recorded since 1558. There were several on the Continent, the last being at Rottingen in 1802; while, what is termed, the Picardy-sweat, or miliary fever, is probably only a modification of the sweating sickness.

The history of this peculiar malady is replete with interest and instruction. We here observe a disease, as severe and nearly as fatal as the plague, springing up spontaneously in a country; and then spreading in a direction directly contrary to that of previous epidemics, *i.e.*, from west to east instead of from east to west. As such, if we infer, that the plague and other diseases progressed in the direction of human intercourse; we must conclude, that this one travelled against the stream. But that would be an inexplicable anomaly. Nor can we infer, that the disease was generated in the bodies of the English, and then propagated by infection, or contagion, from place to place, and from country to country. The short duration of the epidemic, in each locality visited; and the exemption of foreigners, at a time when Englishmen, dwelling in their midst, were attacked, negatives such a conclusion. This disease, therefore, must have arisen spontaneously, and must have been propagated from place to place, and from country to country, by other and different means than by infection. We may draw the same conclusion with respect to those other intercurrent diseases, that were the invariable accompaniment of the plague—as of other pestilential epidemics—inasmuch as, while one form of disease was prevailing in one country, other and different forms sprang up in others. Thus, while the sweating sickness was prevailing in England, the *Hauptkrankheit*, or brain fever, appeared in Germany; and carried off a great many people. Contemporaries state, that other intercurrent diseases were also very prevalent and very fatal, at this period. In Holland, a disease previously unknown, broke out in January, 1417. It was an inflammatory, spasmodic, affection of the throat, of so peculiar a character, that, unless relief were obtained speedily, the patient would be carried off within twelve hours. Still more singular was the fact, that nearly all those attacked were taken ill on *the same day;* and that the epidemic ceased after eleven days—not a case being observed afterwards. Not so in Basle, where it appeared in the same year, and continued for eight months, destroying, during this period, 2,000 persons. The same affliction prevailed in Alkmaar in 1557, and is described by Forest, who was himself attacked. Here it was neither so severe nor so rapid in its course, only 200 persons having been carried off by it. The outbreak, however, was nearly as simultaneous as in Holland; more than 1,000 people having taken to their beds on the same day. They sickened as suddenly as if they had inhaled a poisonous blast: and it is added: "a thick, stinking, mist had, for several days previously, spread over the land."* We may therefore conclude, with Dr. Hecker, "that the English sweating sickness of 1517 made its appearance, not alone, but surrounded by a whole group of epidemics, and that these were called forth by general morbific influences of an unknown nature."† Thinking it better to complete the history of the sweating sickness, without having to recur to it again and again, we have thus been carried involuntarily into the middle of the 16th century. We must now return, in order to consider the atmospherical, and other phenomena, that occurred during the 15th century.

The winter of 1407 was so severe, that nearly all the small birds in England perished: in 1419, on the other hand, the heat was as great. On three particular days, "the heat," according to the Iolo MS., "was so intense, that numbers of men and women perished in Wales, and birds died on the wing." This year is also designated, in

* Forest. Lib. vi. obs. ix. p. 159.
† *Epidemics of the Middle Ages*, p. 211.

the Irish annals, as "the hot summer—such as the eyes of men never before saw."* But, in 1428, the hay and corn were both destroyed in England, in consequence of heavy rains, which continued from April to November. Then again the frost, in 1433, was so severe, that the Thames was frozen over from London Bridge to Gravesend, from November 24th of this year to February 10th, 1434; and Stowe states, that the river was frozen to its mouth. The cold was as great in Spain; and was accompanied by a severe snow storm, which Villalba states lasted *forty days*, during which vast numbers of cattle perished. Rainy and inclement seasons returned in 1436, and continued to 1440; and a partial famine was the consequence. What is termed the *red* blight destroyed the wheat in 1456; but the year does not appear to have been marked by peculiar atmospherical phenomena. In 1477, the heat was abnormal and excessive, both in England and Ireland, and was followed, in the latter island, by so severe a storm, that "great numbers of people and of cattle, and of buildings, were destroyed by it." Famine, the result alike of murrain and of blight, was general in Europe in 1480. In France, says Mezeray, women and children were obliged to draw the plough from the want of draught cattle. Heavy rains, from 1480 to -85, were followed by "shocking floods and great losses of people and cattle" in England. The humidity of the year 1485 was very remarkable, not only in England but on the Continent. The rain fell in torrents, and inundations occurred in many places; that of the Severn was supposed to have been the greatest ever remembered in England. The five previous years had also been unusually

* In 1421, happened the terrible inundation by which the Zuyder sea was formed. No mention is made of any concussion: the cause, therefore, is somewhat problematical.

wet on the Continent. In consequence of this, there had been extensive inundations of the Po, the Danube, the Tiber, the Rhine, and other rivers. In Spain, the rain fell incessantly from November 11th to December 26th, 1485; the duration, in ordinary years, not being more than two or three days at this period. There were continued rains all the summer and autumn in Ireland also, in 1491, hence it was called "the dismal year." Yet in 1492, the drought was so great as to dry up the rivers. And, lastly, the end of this century was characterized by the appearance of *signacula*—mould, or blood, spots—by the destruction of vegetation from blight, and by a famine in nearly every part of Europe.

With respect to the cosmical phenomena, of this century, earthquakes occurred in Syria, in 1402—when a great wave was produced on the coast, the sea having first retired and left the bottom dry for more than a mile; in Italy, in 1405, and, again, in 1414; in Germany, in 1415; in Italy and Spain, in 1420; in Italy and Great Britain—preceded by a fearful tempest—in 1426; also in Spain, when twenty cities were overthrown; and, again, in Spain, in 1431; in Italy, in 1438; in Hungary, Bohemia, Poland, and Silesia, in 1443; in Germany, in 1444; in Corinthia, in 1449, and in Naples—when many thousands perished; in Italy, in 1456,—forty towns being destroyed, and 60,000 of the inhabitants killed; in Italy, France, and Austria, in 1466-68; in Brescia, in 1471,—accompanied by a storm of hail, the stones being as large as ostrich eggs; in the island of Rhodes, in 1481; and in Constantinople, the island of Candia, and Italy, in 1495.

We have now arrived at the commencement of the 16th century, and we find that, in 1500, "a great murrain was in all parts of Ireland, which destroyed a world of cattle:" being prevalent, at the same time, in England. In the same year, "a sore plague," says Short, "of which 30,000 died, prevailed in London." It continued to 1502, and was then so general, that the King retired, with his Court, to Calais. In 1503, the plague raged in

Sweden, in Germany, in the Netherlands, in France, and in Spain; and was attended by other diseases—cerebral inflammation, putrid fever, and malignant pneumonia. Spangenberg says, the mortality by various, and hitherto *unheard*-of, diseases, at this period, was so great in France, that the survivors fled to the woods, leaving the towns deserted. The consequence was, that the dogs became wild, and had to be destroyed, with the wolves. In the following year, a desolating plague broke out in China, and at Marseilles, as, also, in Portugal, and Ireland. In Italy, *Demonolatria*, or Demonomania, prevailed at this time to a fearful extent, the disease presenting this peculiar form,—the maniacs accused themselves of the most horrid crimes.* Calmeil states, that a thousand victims were burnt in one year, for sorcery, in the district of Como alone. As previously mentioned, petechial fever appeared this year in Italy, for the first time—spreading thence over the rest of Europe. It had prevailed for some time previously in Asia Minor, in Cyprus, and in the neighbouring islands. In 1508, the plague broke out in Sweden, and spread over the North of Europe between that and 1510; in which year influenza became general. "It attacked at once," says Short, "and raged all over Europe, not missing a family, and scarce a person." Theomania (religious mania) appeared in Spain, in 1511, and Lycanthrophy (the barking mania) at Poignez; while the plague broke out in England and Scotland in 1513-14. In the latter year, a murrain raged in England, France, Spain, and Italy, and was particularly fatal in the Venetian States. Fracastero says, that "not only were the wretched cattle swept away, but nearly the whole of the unhappy sheep."†

* Ware's *Annals*. † *De Contagiosis Morbis*, L. 1, cap. 12.

Malignant sore throat, in an epidemic form, preceded the third visitation of the sweating sickness in 1517; on the termination of which the plague broke out. The *hauptkrankheit,* or brain fever, prevailed, at the same time, epidemically in Europe. The plague was still existing in 1520-21, in England, Scotland, and Ireland, and in 1522, -25, and -29, in Italy. It carried off 50,000 persons in Milan, one-third of the inhabitants of Cremona, and, in Rome and Naples, *nine-tenths* of the people, according to Bugatti. It was raging at the same time in Spain, together with some form of mania, as we may presume, for fifty women were scourged, and many burned, in 1527, for witchcraft. In 1528, almost the entire French army, before Naples, was destroyed by spotted fever. This fever, which differed from the purple fever, and which appeared first in the Levant, was then unknown in the rest of Europe. At the same time, or in the same year, the fourth part of the population of France was cut off by a disease named the *Trousse-galant*;* which only attacked those in the prime of life, and hence the addition of the adjective—*galant.* This disease, which has been described by the celebrated French surgeon, Parè, was a highly inflammatory fever, of a peculiar type, and was unknown in France before 1528.† It generally caused the death of the patient—or, as Mezeray terms it, *son homme:* if he escaped, it was with the loss of his hair and nails; while the subsequent debility was great and the convalescence long and tedious. This year also corresponds with the fourth visitation of the sweating sickness.‡ A frightful outbreak of plague occurred in

* *Trousse,* means speedy death! † *Ouvrages.* Liv. 22, c. 5, p. 823.

‡ "The plague of pest being hot in the City of London, *blue crosses* were ordered to be set over the doors of houses infected!" *Stowe's Chron.*

Portugal, in 1531; and Skenkius states, that during its prevalence in Narbonne, in 1534, men fell dead suddenly as they were walking. About this time, a plague, called in the Swedish chronicles, "The Great Pestilence," raged in Sweden, and in the North of Europe; and a few years after, or in 1538-9, dysentery prevailed epidemically all over Europe; it was accompanied by a severe fever, and, in England, by *malignant* ague.* A murrain among cattle was also prevalent in these years in Switzerland, Germany, and other parts of the Continent. In Germany, this or some other disease attacked the pigs at the same time.

In 1540, the plague was in Poland; in 1541, in Constantinople and London, and in Hungary the following year. In 1543, plague and petechial fever raged in Germany, while the former disease was general in Scotland, in 1545; and so fatal, that "the number of the dead," as stated in the Scotch Acts of Parliament, "exceeded the number of the living." In the last year, the *Trousse-galant* broke out again, and decimated France. The Duke of Orleans, second son of Francis I., died of it, in the neighbourhood of Boulogne; as, also, numbers of the French troops, and 10,000 British troops, then in the fort. While this disease was raging in France, the Netherlands were visited with the plague, and London and Sweden, in 1547-8. In addition to plague, a peripneumony prevailed in Europe, which was so fatal, and "so contagious," says Short, "that not only the touch, company, or *consanguinity*, but even *the look of the sick*, infected." According to Calmeil, demonomania became epidemic, in the middle of this century, and was particularly prevalent in the convents, and educational establishments in Holland. A great mortality is mentioned as

* Erasmus died of dysentery two years previously, or in 1536.

having occurred among the cattle and sheep in England in 1543: and the price of mutton was raised to 2*s*. 6*d*. a pound—an extraordinary price at that period. Both plague and petechial fever, of a very malignant type, broke out in Germany in 1549; and, in the following year, half the inhabitants of Milan were carried off by plague. It prevailed in Holland and England, also, in 1557-59, being accompanied by malignant fevers, small-pox, and spotted fever. In the latter year, a murrain is stated to have destroyed large numbers of cattle in Germany, and, also, in the Venetian States. In 1562, there was another severe outbreak of plague in England: it commenced among the troops *guarding the coast* at Newcastle. In London, 20,000 died within the Bills of Mortality only. In France and Switzerland, four-fifths of the inhabitants were carried off in 1564, according to Muratori: while, in the following year, 18,000 persons died in Stockholm from the plague, which continued its ravages for two years in Sweden. In 1566, an epidemic, termed *Morbus Hungaricus*, a form of petechial fever, broke out in Hungary, and spread over Europe. The plague again visited England in 1570, and continued until 1574. In the latter year, epidemic madness was so general in Savoy, that 80 monomaniacs were buried in one grave. Whether they were burned first has not been stated; but we may presume so, as, a few years later, or, in 1578, 400 demoniacs were burned in Languedoc. From 1568 to -78, Asia and Europe were laid waste by pestilential diseases: and the operations of war were entirely suspended in the Turkish Empire in consequence. The year 1577 is memorable for what was called the "Black Assizes," and the outbreak of fever at Oxford: it carried off 510 persons from the 5th to the 12th July. The plague, at this time, was prevailing in Ireland, and

Dublin was nearly depopulated, so much so that grass grew in the streets.

Epidemic catarrh sprung up in Constantinople, in 1580, and spread thence to Italy, France, England, Holland, and, ultimately, Norway and Russia—thus taking the opposite course, it may be remarked, to the influenzas of the present day. It was very fatal. In Rome, 5,000 persons died of it; 8,000, in Lübeck; 4,000, in Hamburg, and multitudes in other places. It spread over the whole of Spain, and appeared in Madrid, which it half depopulated, in August. In the same year, the plague broke out in Marseilles, and extended over the whole of Provence, where it was called, *La grande peste.* It was raging, at this time, in Cairo, and carried off, according to Prosper Alpinus, 500,000 souls: and, in the following year, 40,000 died in Paris. There was a great mortality in Spain, also, from the ravages of the plague, in 1582, -3, and -4. It prevailed in this country, again, from 1587 to 1604, and was unusually destructive in 1596. The brute creation suffered, at the same time; rabies, or hydrophobia, being epidemic in Europe, in 1586, and, at the same time, in Turkey. There had also been a murrain in England in 1581, and a great mortality of cattle in Ireland in 1572. In 1591, the plague broke out in Narva, Revel, and Livonia, in the Gulf of Finland—59° north latitude—and continued, with great violence, through the succeeding winter. It appeared, at the same time, in Italy—in Umbria, Lombardy, the Romagna, and Tuscany—carrying off, in some towns, almost every male but very few females. It was followed, in 1592, by spotted fever, in which year the plague prevailed epidemically in England, causing the death, in that and the subsequent year, of 21,955 persons in London alone. A convulsive disease, attended with fever and mania, made its appearance in Germany, in 1596; while "a mortal plague" raged in Flanders, and a malignant fever in England. Two years after, Constantinople was ravaged by so destructive a plague, that the city was almost depopulated. No less than seventeen princesses, sisters of the Sultan Mahomet III., died in *one day*. A mortal plague prevailed in Flanders at the same time. There was another visitation of plague in England, in 1598-99 —in London, Lichfield, Leicester, Kendal, Carlisle, Penrith, Richmond, and other towns. A murrain, which was particularly fatal in the Venetian States, and which carried off large numbers of cattle in Germany, during the two previous years, closes the catalogue of pestilences and murrains for this century.

The atmospherical phenomena of this century commenced, in 1500, by the appearance of mould, or blood-spots—*signacula*—in Germany and in France. In 1502, there was a blight in corn, and swarms of caterpillars in Germany, and, in 1504, so great a drought, that there was a general failure of the corn crops, together with grass and hay. This added to the ravages of the murrain, that then prevailed: so that herds of cattle, driven out in the morning, lost two-thirds before their return in the evening.* As a matter of course, a famine was the result. The following year was a wet one. In addition to red rain, *signacula* were so abundant on the dresses of females, that they caused, says Mezeray, general alarm. In Ireland, a great dearth of corn was produced by the continual and heavy falls of rain. These abnormal rains continued during the next year, and were then attended by severe and heavy thunderstorms. In 1507, Spain was infested by swarms of locusts. There must also have been mists and blue mould on the grass at this period, as

* *Mansfield Chron.* Book 1, p. 402.

Wirth states, that several persons were *executed* in Saxony, on the charge of having spread poison on the pastures. Hecker mentions the same fact, and states, that the severe murrain, which then prevailed, was attributed to these supposed poisoners—*böse Büben*, or wicked knaves.

There was an inundation of the sea in England, in 1521; and a severe and extended storm, on the 10th August, 1527, in Germany, laid whole districts under water, and swept away hundreds of human beings in the floods. In Upper Italy, such considerable floods occurred in all the river districts, in 1527, that the astrologers announced a new deluge. In other parts of Europe, and particularly in November, 1527, and January, 1528, heavy rains deluged the country; the rivers overflowed their banks, and the winter seed rotted in the ground. The weather then remained dry until April, but scarcely was the summer seed sown, when the rain again set in, and continued, day and night, for full eight weeks, so that the last hope of a harvest was then destroyed. The winter of 1529 was particularly mild; but, in the spring and summer, constant torrents of rain, we are told, overflowed the fields, the rivers passed their banks, and all hopes of cultivation were entirely frustrated. In October of the following year, the Tiber rose so much above its banks that, in Rome and its neighbourhood, above 12,000 people were drowned. A heavy rain of four days' continuance, that was experienced in the South of Germany, in the middle of June, 1529, and which was called the St. Vitus's torrent, is still remembered, in modern times, as an-unheard of event. A famine, which prevailed in Germany, France, and England, in 1527, may be ascribed, in part, to these irregularities, and in part to blight, as the scarcity was felt before the great atmospherical vicissitudes commenced.

The preceding aberrations were succeeded, as usual, by the opposite state—heat and drought. "From the year 1533," says Mezeray, "the economy of this lower world was so deranged by the malign influence of the stars, that had it not been for the unequal duration of the days, people would not have known what period of the year it was. The summer mastered the other three seasons, and occupied their place—even that of winter, its opponent. For five years there had been no frost to last more than a day, but continual heat: so that no sooner had the trees shed their leaves, than blossoms sprang forth, which fell without producing any fruit." The grain also was destroyed, as soon as it sprang up, by the devastation of insects; and hence arose a famine, which, increasing year by year, carried off, "nearly the fourth part of the inhabitants of France." (*Tome* 2, p. 966.) In 1540, also, the summer was so remarkably hot, that forests took fire spontaneously, and the Thames and other rivers were dried up. In 1543, a swarm of locusts appeared in Turkey, and, passing through Austria and Italy, reached Spain the same year. They travelled with such rapidity, and were so destructive, that, to quote the language of a Spanish writer, the whole world stood aghast.* Subsequently to this, or in 1549, there was a blight, with great destruction of vegetation by caterpillars in different parts of Europe. In 1554, perpetual rains and storms were experienced in Ireland, from December to the end of the spring; while it is mentioned, that there was a shower of fish in 1556.† There was also a blight, this year, in corn

* Fonzano. *Anales de Aragon.*

† This phenomenon has been observed at various times, and is to be ascribed to a tornado in an adjoining or distant sea; during the whirl of which the fish, having been carried up into the higher regions, are transported to a greater or less distance, and then deposited in another locality, according to the direction of the wind, and the extent of the tornado.

in Ireland; and in England, in 1561, with subsequent scarcity. The years 1568, -77, and -82, were remarkable for violent storms, and in the following years for the heavy rains. But, in 1591, the drought was so severe, that the Thames was fordable at London Bridge. These circumstances, combined probably with blight, produced a severe famine, during which multitudes of people perished in all parts of Europe, and particularly in Hungary, in 1590.

Cosmical phenomena of the 16th century. An earthquake occurred in the Island of Candia, in 1501; in Italy, in 1503; in Switzerland, Belgium, Spain, and Portugal, in 1504—1,500 houses and 20,000 people having been destroyed in Lisbon; in Afghanistan and Italy—30 shocks in a day, and lasting many weeks—in 1505; and in Turkey, in 1509. Many towns were destroyed: the sea rushed over the walls of Constantinople, which were thrown down, together with 1,700 houses: and some thousands perished in the ruins, or were drowned. In the following year, during an earthquake in Bavaria, the church of St. Emeran, in Nordlingen, was completely forced out of the ground; between 1,000 and 2,000 houses, for a space of two miles, were overthrown, and a great many lives sacrificed. A violent storm occurred at the same time. In 1511, a concussion was felt in Japan, Carinthia and Italy; in Cabul, a violent one, in 1119; in Italy and Switzerland, in 1520 and -24; in Germany, in 1528; and in Flanders and Holland, in 1530. Either during the concussion, or subsequently, a great part of Holland, Zetland, and Flanders were submerged by the ocean. There were earthquakes in 1531, in the North of Africa, in Switzerland, in Spain, and in Portugal —1,500 houses, and all the churches, being thrown down in Lisbon. Concussions occurred also in Lisbon in 1532; in Italy,—attended by an eruption of Etna,—in 1537-8; in Syracuse, in Turkey, Italy, and Sicily,—many towns being ruined—in 1542; in Europe generally, in 1545; in Palestine, in 1546; in Italy, Portugal, and England, in 1551; in Hungary, Germany, and Switzerland, in 1552; in China, in 1555, and again in 1556, when a lake was produced 60 leagues in circumference. In 1556, concussions were felt in Japan, in Turkey, in Hungary, Austria, Bavaria, Croatia, Dalmatia, &c.—26 townships being destroyed in the last named countries; in Italy, in 1558; in Vienna, in 1559, attended by a disastrous inundation; in Provence, where seven villages were ruined, in 1564; in Constantinople, in Cyprus, Germany, and Flanders, in 1568, together with an inundation of the sea at Friesland; in the Grecian Archipelago, in Italy—84 shocks in three days—and in Germany, in 1570; in Prussia and Switzerland, in 1572; in Switzerland and England, in 1574; in Lisbon and England, in 1575; on the borders of the Mediterranean, in Spain, France, Germany, Flanders, and England, in 1580; in Switzerland, Italy, and France, in 1584; in the Azores, in 1591—all vessels within 20 leagues being greatly shaken and injured; in Japan, in 1595 and -96, as, also, in Italy, in Portugal, and Scotland; and, lastly, in Calabria, in 1599, together with heavy and continuous rains, floods, and inundations.

"Pestilences of the 17th century." A memorable event, the discovery of America—not only important in the history of the world, but, also, in the history of diseases—marks the commencement of this century. As the New World had been entirely separated from the Old previously, or, at all events, during historical periods; and as they are separated from each other by the waters of the great Atlantic, we might have been led to infer, that the diseases of the one would have been different to those of the other. On the contrary, we shall find that, with one solitary exception, such is not the case. The yellow fever prevails there the same as in the West Indies; but all the other diseases are identical with those prevalent in Europe. The cause of the phenomenon, as, also, of the variation, will be evident from what has gone before. As will be remembered, the Volcanic Band of the West Indies extends along the eastern shore of the continent of America; while it has been shown, that the yellow fever is confined to this region, or band. Hence its prevalence in America. But this is not the only volcanic line that traverses the American continent: the Mediterranean Band crosses the northern part of America, as previously mentioned; and as will be more particularly shown hereafter. Hence, if epidemic diseases be effects of the process that is going on beneath the surface, we should expect to find, that some of the diseases of America would be intimately connected with those of Europe; not only as regards their nature, but, also, their prevalence, progress, and duration. Whether such be the case, or not, will be evident as we proceed. It is necessary, however, to remark, that as no precise accounts could be derived from the Indians, and as the plague disappeared altogether, in some places in Europe, in the middle of this century, we can hardly expect to hear much of the ravages of this disease in America. Added to this, America is at one extremity of the band; so that the effects resulting from the subterranean action would probably be less than in Europe, or in the central portion of the region. With these remarks we may now proceed with our historical detail.

In 1600, an epidemic and mortal "colic" affected all Europe; and Italy in 1607. Epidemic visitations of colic have been seldom noticed, although they no doubt prevailed, having been frequently recorded in the Irish Annals; while there is hardly a year in which deaths from colic have not been entered in the Old Bills of Mortality for London. In addition to colic, other diseases were raging in all parts of Europe, from the very commencement of this century. Plague prevailed in Spain, and malignant fevers in Portugal, in 1600-2; while, in 1603, England suffered from a severe outbreak of the plague; the deaths, in London alone, amounting to 36,269. This visitation lasted until 1611; and Short states, that 68,596 were carried off in London, in 1606. In Ireland, where it was termed the "Great Plague," the disease spread over the whole country, in 1604, having been preceded by influenza. In the following year, the spotted fever prevailed over the whole of Spain; "attacking indifferently," says Villalba, "the young and the old; the cold and the hot temperaments; the rich and the poor." In 1610, a new disease, the "Angina maligna," or putrid sore throat, made its appearance; and committed great ravages in Malta, Sicily, Naples, and Spain. Nola, an Italian physician, was the first to describe it; although Fontecha had referred to it previously, as a new disease in Spain, under the name of *Garotillo,* or strangulation. It attacked horses, cattle, and pigs, as well as men. In 1613, angina prevailed to such an extent in Spain, that it was called *el año de los garotillos.* A fatal disease of the mouth was also prevalent in other parts of Europe, at the same time; while catarrh was general in all countries. In addition to angina, Demonopathy raged in Spain, in 1610; and the "Barking mania" in some parts of France. In 1616, the plague broke out in Egypt, the Levant, Denmark, and Norway; the angina maligna in Naples, and anthrax (*ignea pestis*) in Italy, the islands of the Mediterranean, and Spain. The last-named disease prevailed epidemically in Europe for 22 years. In Italy, a murrain among cattle raged contemporaneously with pestilence in man.

The first account, that has been recorded, of pestilence in the New World was in 1618. Captain Dermer states, that he passed the winter of this year in Montriggon, an Indian town, and returned there in 1619. On his arrival, he found many of the towns depopulated from sickness; "their disease the plague, for we might perceive the sores of some that had escaped, who described the spots of such as usually die."* Webster remarks, that Richard Vines and his companions, who wintered among these Indians during the pestilence, were not attacked: we may therefore conclude, that the plague was not imported, but sprang up

* Purchas, Vol. 4.

there spontaneously. This is an important fact, and annihilates, at one blow, all the vain arguments and hypotheses of the contagionists, as regards the propagation of plague from country to country. The disease must have prevailed for some years, or, else, there was another outbreak, for some of the Plymouth settlers went to Massachusetts (now Boston) in 1622, to purchase corn of the natives; and "found among the Indians a great sickness, *not unlike the plague*, if not the same." It raged in winter, and afflicted the Indians only. There would also appear to have been a visitation of a different kind among the Indians some years before this. General Gookin, in his account of the Indians (*Historical Collections*, p. 8), places this pestilence in 1612 and -13, about 7 or 8 years before the English arrived at Plymouth. He remarks: "What the disease was, which so generally and mortally swept them away, I cannot learn. . . . I have discoursed with some old Indians, that were then youths, who say, that the bodies all over were *exceeding yellow* (describing it by a yellow garment they showed me), both before they died and afterwards." This disease, therefore, must have been yellow fever, not plague. Referring to this visitation, Noah Webster states, that no intercourse existed at this period between the American continent and the West Indies; nor did a single vessel pass between New England and these islands until 28 years after. Besides, this visitation actually occurred before the arrival of any settlers in North America. "The evidence, then, of the origin of the yellow fever in this country, between the 41st and 44th degree of latitude, is complete, leaving no room for doubt or controversy." (*Loc. cit.*, vol. i., p. 178.)

The plague was present in Sicily in 1625, and broke out, with great violence, in England the same year or in 1622, according to some writers. Be this as it may, the deaths in London, in 1625, from plague, amounted to 35,417, and, from other diseases, to 18,848; while the christenings were only 6,983. The deaths, in one week, were 3,000, equivalent to 30,000 with the present population. On the Continent, the epidemic commenced the year before, and raged in Denmark, Holland, Italy, and France, for some years. Lyons lost 60,000 of its inhabitants in one year—1626. There had been a murrain in Italy in 1616, but a more general one prevailed on the Continent, in 1625; having commenced in Hungary, and having thence extended to other countries. It does not appear, however, to have reached either England or Ireland at this time. Small-pox broke out in America, in 1635, among the Indians, who were swept away in multitudes. It spread, says Webster, from Narragansett to Piscatagua, and westward to Connecticut River. A "pestilent fever," as it is termed, invaded the small colony, at Massachusetts, and carried off a large proportion of their number, in the same year. There was another visitation of the plague in England, in 1636, but the ravages of the disease were less than at the previous one; the deaths in London, from this disease, only amounting to 10,400, and from other diseases to 12,959. It thus appears that the mortality from ordinary diseases—some not considered to be contagious—bears a strict ratio to that of the reigning epidemic—a result that is entirely opposed to the doctrine of contagion. On the Continent, the plague assumed a more severe type. In Leyden, 20,000 of the inhabitants were carried off in one year. In Prague, 17,000 Christians and 20,000 Jews died of it, in 1637; while 1,500 died daily in Constantinople, during the height of the visitation of this year. The plague broke out in Edinburgh in 1643, and then spread over the rest of Scotland. It continued its ravages for 4 years; and, in 1645, carried off 30,000 persons in Leith, between April and December.* In 1644, a great part of the population of Madrid fell victims to the ravages of a malignant fever—the *avant courier* of the plague, that broke out, in 1647, in Murcia, Valencia, and Catalonia. It continued to devastate these provinces during the whole of the next year; spreading, at the same time, to Saragossa and the western parts of the Peninsula. The whole of Seville, in 1649, was, it is stated, like a vast hospital, so general was the plague; which would appear to have been prevailing in Andalusia since 1646. Altogether 200,000 are supposed to have been carried off, in 1649, in Spain: and Dr. Acevado states, that 40,000 perished in Malaga alone from plague.† This disease was again raging in 1650, in Aragon, Valencia, and Catalonia, principally in the small towns and villages; but, in the following year, it extended to the large towns, where it caused great ravages, and did not subside for two years. It was prevailing in France, at the same time; as, also, in the island of Sardinia, which was nearly depopulated; the effect of which has been felt to almost the present time. In 1654, the plague broke out at the same time, or season, in Turkey, Hungary, and Russia, committing great ravages in each of these countries. In Moscow alone, 200,000 are stated to have perished. The epidemic did not make its appearance until two years after in the South of Europe—an exception to the general course of the disease: but it had lost none of its malignancy in the interval. Cardinal Gastaldi states, that Rome suffered, in 1656, from the most dreadful pestilence that was ever seen; while, at the end of May, from 1,300 to 1,400 died *daily* in Naples.‡ On

* Laing's *MSS.* † *Tratado de peste.*
‡ *De Avertenda et profliganda peste*, p. 107.

the 6th June, 80,000 persons were sick, so that there were neither nurses to attend them, nor people to bury the dead. It began to decline in August, after carrying off nearly the whole population: or, according to some writers, 240,000 out of a population of 290,000. At Genoa, 10,000 died, in 1656, and 70,000 in 1657, leaving only 14,000 alive. Benevento, it is said, lost 9,000 out of 9,500, and other cities in like proportion.

Cynanche Trachealis prevailed in America in 1659, this being the first mention of the disease in that country. There was, also, much sickness in 1660, and the subsequent years, but the nature of the disease is not mentioned—probably, malignant fever, as the plague was raging at this time in Europe; a severe visitation having occurred in Denmark in 1660, and in Holland in 1663-4. These were followed, in 1665, by the memorable outbreak in England; which had been preceded, as usual, by other diseases. In 1661, intermittent fevers, which had been general some years before, put on a malignant form, and continued to prevail until the irruption of the plague;* which was accompanied by a severe continued fever—the one disease, according to Sydenham, running occasionally into the other. In the spring, quinsies, and other inflammatory diseases, made their appearance, and were very fatal. To these succeeded a continued fever, differing, according to the above authority, from that which had prevailed in the previous years. This was the precursor of the plague, for, at the close of 1664, two or three persons died suddenly in Westminster, *with the marks of plague on their bodies.* No fresh cases occurred until February, 1665, when the disease appeared in St. Giles'; but subsided again until April, when it broke out afresh,

* For proof of the connection between intermittent fever and plague, see Chapter 1, Part 1.

and continued to spread; arriving at its height in the autumn. It disappeared altogether in February, 1666: since which it has ceased to prevail epidemically in England: sporadic cases only having been observed in subsequent years. According to the Bills of Mortality, the number that died of plague in London, during this visitation, was 68,596; but Lord Clarendon states, that the actual number was not less than 100,000. This, we can readily understand, as the Bills of Mortality only included the burials in the churches and churchyards; and those buried according to the rites of the Church of England; they do not include those buried without the walls, in the cemeteries of the Dissenters, and Roman Catholics. The Quakers alone, it has been stated, buried 1,000 in one week. We cannot err much, therefore, in setting down the actual number, that died of plague in London, during this visitation, at 100,000—a number equivalent to between 500,000 and 600,000, calculated on the present population. These returns do not give the total loss, as the plague prevailed to a slight extent in the following years. Thus, 1,998 persons died of plague in London the year after the subsidence of the epidemic; 35 in 1667, and 14 in 1668. In the previous visitations, the duration of the disease was longer. The Plague of 1603, lasted 8 years, the deaths, in these years, varying from 600 to 4,000. That of 1636 lasted 12 years, during which period there died, generally, about 2,000, never less than 300. "The which shows," as Captain Graunt rightly remarks, "that the contagion of the plague depends more upon the disposition of the air than upon the effluvia from the bodies of men. . . . Which also we prove by the sudden jumps, which the plague hath made; leaping, in one week, from 118 to 927, and back again from 993 to 258; and from thence again, the very next week, to 852." * Independently of the years, immediately following a general visitation, there were few years in which isolated, or sporadic, cases, as they are termed, did not occur. From 1602 to 1680, there were only four years in which deaths from plague have not been recorded; the deaths varying, in those years in which the plague did not prevail epidemically, from 100 to 200. Yet the plague did not spread in those years when there were 400 or 500 cases—taking the mortality at one-half—any more than when there were only 4 or 5—a sure proof that the disease is caused and propagated by other means than by contagion. In addition to plague, the deaths in London, in 1665, from other diseases, amounted to 28,710, of which number 1,929 were from spotted fever. Captain Graunt states, that before the plague commenced there would not be, probably, one death from spotted fever. But, in the first week of the plague, there die 12; and, afterwards, the number increases as the plague increases, so that there frequently die a hundred and more, or 200 in the week. The number of those likewise, who die of *ordinary* fever, may, according to the above writer, be observed to rise every week with the plague, and to decrease with it; so that, in the whole year, the number of deaths by fever is 5 times as great as that of ordinary years.

As this was the last visitation of the plague in London,†

* Observations on the Bills of Mortality, 1676.

† It has been frequently stated, and is generally supposed, that the cessation of the plague in London is to be ascribed to the great fire that occurred the same year. Nothing can be more erroneous than such a belief. The plague ceased in February, but the fire did not occur until November. Added to this, the plague ceased, at the same time, in all the other towns in Great Britain: in Paris, Switzerland, and other places on the Continent,

it may not be uninteresting to add, that nine great, or general, visitations of the plague, in London, have been recorded. These were in 1541, -62, -70, -92, and -98; 1603, -25, -36, and -65. Short states, that for the 200 years, from 1541 to 1741, the very healthy years are to the fatal as 23 or 24 to 8 = 3 to 1; and to the moderately fatal, as 23 or 24 to 13 or 14 = 2 to 1. It is evident, however, from what has gone before, that these were not all the visitations of plague in England; this disease having prevailed in Europe from the middle of the 6th century, if not before. But, as the *causes* of disease were not set down in the Bills of Mortality until the end of the 16th century, we can thus account for the want of reference to previous outbreaks. Dr. Rossi gives 22, as the number of visitations in England, but this even is under the mark.* As, also, it has been shown, that all other, or ordinary, diseases assumed a more malignant type during the reign of the plague, the amount of misery, which this disease brought in its train, will be at once apparent. Subsequently to the subsidence of the plague in England, it broke out in Denmark, in 1660; at Amsterdam and Hamburg, in 1663-4; in Flanders, in 1668; at Oran, Africa, in 1676; in Andalusia, Austria, and Hungary, in 1679; at Leipzic, in 1680; in Norway, in 1684; and in Leghorn, Genoa, Sardinia, and Nismes, in 1699.

although no such cause could be assigned for its cessation there. More than this: there had been two great fires in London previously, viz. in 962 and 1087. In the latter year, according to the *Anglo-Saxon Chronicle*, "St. Paul's Minster and the Bishop's Palace, together with many *other monasteries*, and the greater and handsomer parts of the whole city of London, were burned down." But this fire, great as it was, had no effect in preventing the return, or mitigating the ravages, of the plague.

* See Table 2, Part 1, p. 78, as, also, for the number of visitations of plague in other countries.

Turning to other and ordinary diseases, we find that, in the autumn of 1667, small-pox, which, during the epidemic constitution of the previous two years, had not appeared, or only occasionally, began to show itself in London; and, increasing from day to day, became very prevalent in the autumn. It subsided at the approach of cold weather, only to re-appear, the following spring, with increased violence. It continued to rage until the winter, when it declined a second time, but returned once more in the spring, only in a milder form. It ceased entirely in August, and was replaced by epidemic dysentery. Sydenham states, that this visitation was more general than any other that he remembered. It was also accompanied by a continued fever. Both diseases (dysentery and fever) continued to prevail epidemically until the end of 1672. In 1676, Tercianas, in a malignant form, prevailed in the province of Murcia; and malignant fevers, accompanied by carbuncles and buboes, raged in the southern parts of Spain, as well as malignant agues, which were accompanied by swooning. These affections continued to prevail in 1677-79, and Avicenna states that, although not plague, they resembled it to a great extent. It may be remarked that the plague raged, at this time, in Morocco and Algiers, four millions, it has been calculated, having perished; while it has been stated by some authors, that the waste of population has not since been repaired. What was termed the "Hungry fever" prevailed in Europe in 1683. This singular malady was characterized by an intense desire for food, which, if indulged in, was fatal. Spotted fever, small-pox, and other diseases were general in Europe, in 1689. In the Duke of Schromberg's army, in Ireland, fever and dysentery raged to such an extent, that, in some regiments, three-fourths—or 870 men out of 1,000—were carried off.* In 1695, small-pox prevailed in Germany, and Hegman states, that it attacked geese, fowls, and pigeons.† This is not uncommon in India with fowls. Apoplexies were epidemic in Italy, and sudden deaths of daily occurence—results very frequently observed at pestilential epochs. In 1697-8, "Typhus, which," says Webster, "has often proved a terrible scourge to particular parts of America, *during the rage of pestilence in the east*, was very prevalent on that continent." At this period, dysentery was raging in England, and so fatally in South Wales, that, "in some families, scarcely one survived to bury the dead." This was accompanied by spotted fever; while, in Spain, angina maligna was so fatal, that few of those attacked survived.

The pestilential principle, during the period just described, was not confined to the human race. The fish died in the lakes and ponds in England, in 1655; and a singular malady—a kind of frensy—broke out in Germany. It was observed principally among horses, oxen, and sheep, and drove them mad. The years 1663-4, and -5 were also fatal to animals in Germany, and particularly to the sheep; only 40 out of a flock of 3,000, belonging to one farmer, having escaped. Even the fœtus became diseased; but, with cattle, only calves and heifers under two years of age were attacked. The murrain was equally prevalent and severe in Italy, 60,000 cattle having been carried off in the Venetian territories, in 1663.‡ It commenced in England shortly before the memorable plague of 1665; and also on the Continent, where it was very fatal. In Prussia and Holland, the carcases of those that

* Story's *History of the Wars in Ireland.*

† *Ephem. Nat. Curios,* V. 2, p. 386.

‡ Paulet. *Recherches sur les Maladies Epizootiques,* p. 97, 1775.

died were ordered to be buried, under *pain of death!* Cats and dogs died in Vienna, during the prevalence of the plague there in 1679; while in Hungary, an unknown winged insect appeared, and caused a great mortality by its sting. In 1682, the murrain described by Dr. Wincler, and stated to be *gloss-anthrax*, or carbuncle of the tongue, made its appearance. The course of this disease was singular and rapid. The cattle, even when at work, although they appeared to be in their usual health, suddenly fell down and expired. On dissection, gangrenous spots were found in the mouth, and in the intestines; the former, it is stated, having been produced in the course of only four or five hours.* As this murrain has been already referred to in a previous chapter, and, also, in the first part of the work, it is not necessary to describe its route and progress more particularly. Ramazzini states, that a great mortality occurred among animals in Italy in 1690, from what was evidently small-pox. Pigs were carried off by troops, and cattle died even at the plough; those that recovered from the attack dying afterwards from debility. The disease extended even to the silkworms and the bees. This author attributed the disease *à la rouille des herbes.* The year 1691 was no less fatal to animals than the preceding—the sheep being nearly all destroyed. And, lastly, in 1693, the greater part of the cattle, in the Grand Duchy of Hesse, were carried off by a fatal pneumonia.

Atmospherical phenomena of the 17th century. In 1602, there was a failure of the crops in almost every part of Europe; at the very time that the plague was committing desolating ravages. In Russia, the famine was so severe, that all the ties of nature and morality were disregarded; and human flesh was exposed for sale

* *Journal des Savans*, November, 1682.

in the open market. The more powerful seized their neighbours; fathers and mothers their children; husbands their wives, and offered them for sale. It is supposed, that 500,000 perished, in this country, from the combined effect of famine and pestilence. Five towns were destroyed in England by a violent storm, that occurred in 1607, attended by an unexampled inundation of the sea, extending over the counties of Gloucestershire, Monmouthshire, Somersetshire, and other parts of the country. The following graphic account, taken from a pamphlet upwards of a hundred years old, and preserved in the Harleian Library, will, with its quaint phraseology, give the reader the best idea of the extent of the catastrophe :—

"On Tuesday, January 27" (says the author), "about nine in the morning, the sun being *fayrly and bryghtly spred*, huge and mighty hills of water were seen in the elements, tumbling one over another in such sort as if the greatest mountains in the world had overwhelmed the low valleys, to the inexpressible astonishment and terror of the spectators, who, at first, mistaking it for a great mist, or fog, did not on the sudden prepare to make their escape from it; but, on its nearer approach, which came on with such swiftness as it was verily thought the fowls of the air could not fly so fast, they perceived that it was the violence of the waters of the raging seas, which seemed to have broken their bounds, and were pouring in to deluge the whole land, and then happy were they that could fly the fastest. But so violent and swift were the huge waves, and they pursuing one another with such rapidity that, in less than five hours' space, most part of the countries on the Severn's banks were laid under water, and many hundreds of men, women, and children perished in the floods. From the hills might be seen herds of cattle and flocks of sheep, with husbandmen labouring in the fields, all swept away together and swallowed up in one dreadful inundation. Houses, barns, ricks of corn, and hay were all involved in the common ruin. Many who were rich in the morning were beggars before noon, and several perished in endeavouring to save their effects. . . . Bristol and Aust suffered terribly, and all the country from Bristol to Gloucester, on both sides the

Severn, was overflowed to the distance of six miles, and most of the bridges over it and the adjacent buildings were destroyed or defaced. At Chepstow, Goldcliff, Matherde, Callcott-Moor, Redrift, Newport, Cardiffe, Cowbridge, Swansey, Langherne, and many other parts of Glamorganshire, Monmouthshire, Carmarthenshire, and Cardiganshire, the waters raged so furiously and came on so fast, that, upon a moderate supposition, there cannot be so few persons drowned as 500—men, women, and children, besides many thousand herd of cattle that were feeding in the valleys, together with sheep, hogs, horses, and even poultry, all of which were suddenly immerged in the waters, and could not escape. . . . . Glamorgan, Carmarthen, Cardigan, and other counties in South Wales, bore their part in this dreadful visitation; many, to save their lives, ascended hills, trees, steeples, and houses, where they might see their cattle, and sometimes their wives and children, perish, without being able to give them the least assistance. At Cardiff, a great part of the church next the river was carried away by the violence of the flood."*

Although no mention is made of such an occurrence, the inundation, we may presume, was caused by an earthquake, not by the storm that occurred at the time.

Another severe storm, but unattended with any inundation, occurred in 1611. It caused great destruction among the shipping, 2,000 dead bodies having been cast on the shores of Great Britain, and 1,200 on the coast of Holland. A remarkable snow storm, in England, in 1620, is stated to have continued, or, at least, the fall of snow, for *eighteen days and nights :* accompanied by great cold, and a keen, biting wind. About the 5th or 6th day, the young sheep fell into a torpid state and died; and, on the 9th, the shepherds began to raise semicircular walls with the carcases of the dead, in order to protect the living; but the protection was of little use. On the 14th day, and particularly with high-lying farms, not a survivor, out of even extensive flocks, was to be found.

* This extract, inserted in the *Brighton Gazette*, was taken from a copy of the pamphlet.

In the extensive pastoral district of Eskdale Moor, only 45 remained alive, out of 20,000 sheep.

Instead of cold, heavy and continued rains, with floods and inundations, were general in Europe in 1636. In the province of Valladolid, it rained for 40 days consecutively, and the river Pituerga, overflowing its banks, half the town of Valladolid was destroyed, and many of its inhabitants drowned. In 1640, on the other hand, unusual and intense cold was experienced in Europe, and, in the following year, in America. These winters, which were the most severe that had been known for 40 years, are memorable for the circumstance just mentioned, and before referred to, viz., that the cold was one year later in America than in Europe. It thus obeyed the law of progression the same as pestilences; and, what is of more importance, at present, it thus links the two continents inseparably together; and makes the cause of some of the aberrations, if not all, of the one to be identical with that of the other. It often happens, however, says Webster, that the winter is severe, at the same time, in both hemispheres, as was the case in 1607, -8, -83, -84, 1762, -3, -79, and -80. Instead of cold, so warm a winter occurred in England, in 1661, "as," says Pepys, "was never known in this world, before here." The following circumstance is worthy of note. In 1666, the mildew in wheat appeared, for the first time, in America; and it has been impossible to cultivate this grain, on the Atlantic shore of the three eastern States, since. At least, this was the case, when Webster published his work—in 1800; what may be the case now, I am unable to say. In the same year, a remarkable hurricane was experienced in England; thousands of trees in Nottingham Park were torn up by the roots; while, in one village, 50 houses out of 57 were destroyed. This storm was accompanied by an earthquake in Oxfordshire, and by hail—the stones being as large as hens' eggs. The coldest winter and the longest hoar frost, known in the memory of any living man, occurred in 1683 and -4, both in England and in America. The Thames was frozen over below Gravesend, and trees of the largest size were split by the frost. So great was the cold, that "printing," says Mr. Ashton, "was hindered for a *whole year!*" In 1687, heavy rains caused great inundations on the Continent, during which multitudes of people were drowned. Plagues of insects and partial famines prevailed at the same time. The winter, the following year, was so severe, that the Bosphorus and the Danube were both frozen over. In 1690, rust in corn made its appearance in Italy; and, in the following year, the smut attacked the mulberry trees and other plants in Lombardy. Ramazzini states, that the corn—wheat, barley, and pulse—appeared as if struck by a blast from heaven. Swarms of caterpillars appeared at the same time, and laid waste whole fields. The last seven years of this century were distinguished for a severe and continued famine in Scotland. Vast multitudes perished with hunger, and dead bodies lay scattered along the highways. This famine appears to have been caused by the inclemency of the weather—or the wet and cold summer. A famine prevailed, at the same time, in Finland; and carried off one-tenth of the inhabitants. In America, also, the same effects were experienced, although not to the same extent. And, lastly, a blight, or, as it is termed, blast on the corn, occurred in America, in 1691.

We may now turn to the cosmical phenomena that occurred during this century. In 1600 violent earthquakes were experienced in Asia, and throughout the whole of Europe—in Austria, Bohemia, Bavaria, Swabia, Alsace, the Netherlands, and England. They were felt again in 1607, in Switzerland, Germany, and Scotland; in 1612, in the Mediterranean, in France, and in Germany; in 1614, in Transylvania, Switzerland, Calabria, and the Azores; in 1616, in Aleppo, Italy, and Switzerland; in 1619, in Germany and Switzerland; in 1623, in Germany and Norway—the last being more violent than any previous one; in 1626, in Smyrna, Ragusa, Carinthia, Calabria—30 towns and villages being more or less injured, and 17,000 persons killed; in 1628, in the Azores, when an island more than 1½ leagues long was raised in 150 fathoms water; in 1629, in Africa and in Italy, when 7,000 persons perished in La Puglia; in 1630, in the Azores; in 1631, in Italy, followed by an eruption of Vesuvius—the greatest that had occurred since that in A.D. 79; in 1633, in Constantinople, Egypt, and Italy; in 1636, in Zante, the Island of Rhodes, Italy, and the Azores, with a submarine eruption, and the up-heaving of a new island 5 miles long; in 1638, in Sicily, Calabria—memorable for the destruction of 180 towns, and the loss of 30,000 lives—Switzerland, England, and America. The last extended from the Piscataqua to the Connecticut, and, perhaps, over the whole northern region of this continent.* In 1640, earthquakes were experienced in Asia Minor, Calabria, France, Belgium, Holland, and Germany; in 1642, in the whole of Italy, in Sicily, Switzerland, Germany, and Holland; in 1643, in Sicily, followed by an eruption of Etna and Vesuvius, and attended by intense cold; in 1646, in Turkey, the Adriatic, Italy, and Denmark; in 1650 and -54 in the Island of Santorin and Switzerland—26 shocks in the latter year; in 1654, in Asia Minor, Smyrna, and Naples; in 1657, in Italy, France, Norway, and England; in 1658, in Malta, Messina, Cephalonia, and America. This was called the "Great Earthquake," being more violent than the preceding one. In 1660, the Island of Rhodes, Switzerland, Italy, Spain, France, and New England, were again shaken; in 1661, Malta, Italy, Switzerland, and England; in 1662, Rome, Calabria, the Island of Candia, Japan, and New England. In 1663, Canada was violently convulsed in a district of 400 leagues in circumference, while the shocks continued for five months; an immense ridge of mountains subsided to a plain; small rivers and springs were dried up, and the water of others rendered turbid, having the odour and taste of sulphur. Shocks occurred in 1664-5 in the Island of Zante, Island of Candia, Italy, France, Hungary, Poland, Switzerland, England, and Canada; in 1666, in Assyria—where 5 towns and 45 villages were ruined, and 4 new mountains raised—in Syria, Corfu, Switzerland, Poland, Hungary, Italy, and

* *Phil. Trans.* 1757. Part 1 and 3.

England; in 1667, in Turkey, in Schamaki, or Chamaki—when 80,000 persons perished, while the shocks lasted 3 months—in Smyrna, Dalmatia, Albania, Switzerland, and Italy. In Ragusa, 5,000 persons perished, the shocks being attended by a violent storm. The greater part of Tiflis and 4 villages were also demolished and 30,000 persons swallowed up. In the following year, concussions were felt in China, in Asia Minor, Austria, Lorraine, and on the Rhine; in 1670-1, in Schamaki, Augsburg, Nuremberg, Switzerland, the Tyrol, Italy, the coast of France, England, and Holland; in 1672, in China—at Pekin and other towns—in the Grecian Islands, Italy, and Spain; in 1675, in Turkey, Hungary, Switzerland, Italy, Spain, and England; in 1678, at Erivan, Mount Ararat, Poland, Italy, Spain, and England; in 1681, in the Island of Candia, Moldavia, Germany, Switzerland, Savoy, France, &c; in 1682, at Erivan and the frontiers of Persia, in Turkey and England, with an eruption of Vesuvius; in 1684, at Smyrna, Alexandria, Carinthia, Switzerland, Sicily, and Italy; in 1688, at Constantinople, Smyrna,—when 20,000 persons perished—the Coast of Asia Minor, and the islands of Mesillino, Chie, and Satalin; in 1690, at Constantinople, Swabia, Poland, Transylvania, Germany, Cornicola, Italy, and England; in 1691, in Japan; in 1692, in Italy, France, Germany, Flanders, Holland, and England; in 1693, in Malta, Sicily,—during which 93,000 persons perished, and 972 churches and convents, with many villages, were totally destroyed, and the town of Catania nearly ruined—in Calabria, France, Belgium, Holland, and England, over an area of 2,600 square miles; and, lastly, a concussion and eruption of Vesuvius.

We have now been brought to the commencement of the 18th century—the last, happily, of this pestilential epoch. In 1700, a malignant sore throat, described as "a carbuncle or plague sore," in the bottom of the throat, attended with violent fever, appeared in the island of Milo in the Mediterranean. It carried children off in two days, but spared adults. While this disease was raging in the Levant, children, in *the north of Europe*, were seized with a suffocating catarrh, followed by measles.*

* Referring to the diseases that prevailed at this time, in Italy—malignant fevers, madness, melancholy, &c.—Webster asks, "Are not these effects produced by an excess of stimulus occasioned by the superabundance of electricity?"

In the following year, the barking mania appeared among a family, in the neighbourhood of Oxford, being the last appearance of the disease in England. At this time, the Levant was sorely afflicted by the plague, as, also, the south of France, Toulon having lost two-thirds of its inhabitants. Two years later, or in 1702, it broke out in the north of Europe, leaving the intermediate countries untouched. It first appeared at Pickerau in Poland, and then spread through this country to Hungary and Russia, during the two following years, sweeping away vast numbers of the inhabitants. It re-appeared in Poland in 1707, and, in the following year, in Dantzic, in which city 25,000 people died. The epizootic, termed *chancre volant*, which prevailed generally in Europe in 1682, re-appeared in Switzerland, in 1705, but did not spread as on the former occasion. In 1708, a universal catarrh in Europe was followed by pestilence in man, and murrain in cattle. Although England and the north of France remained exempt, the plague (*bubon-pest*) re-appeared in Germany and Livonia in 1710. It then spread northwards through Denmark and Sweden, but the western parts of this country, and also Norway, entirely escaped. The ravages of the disease, however, in the places invaded, were great. In Carlskrona, 13,000 died; in Copenhagen, 25,000, and 30,000 in Stockholm.* Altogether Sweden lost several hundred thousand men by plague, and the sweating sickness, which prevailed at the same time; and it is stated that this country has been less populous ever since. As more particularly described in a previous chapter, a pestilential plague among cattle commenced in England in 1711, having previously spread through Hungary, Germany, and the other countries of Europe. In England, 70,000 head of cattle died, and in Holland,

* Broberg. *On the Plague in Stockholm.*

200,000. Plague again appeared in the north of Europe in 1712, and became epidemic in Austria, Hungary, and the adjoining eastern countries. In 1717-18, whilesmall-pox prevailed in Italy and Germany, and continued fever in Scotland, miliary fever—an affection somewhat analogous to the sweating sickness—broke out in France. It first appeared in Picardy,—hence termed the Picardy sweat,—and then spread through France and Piedmont, but did not reach England. In Ireland, dysenteries of a very malignant type, frequently ending in mortification of the intestines; together with confluent small-pox, *malignant to a degree*, were prevalent at the same time. In 1719, the plague appeared in Aleppo, and carried off, it was calculated, 80,000 inhabitants. In the same year, a pestilential fever prevailed in Marseilles—buboes, carbuncles, and swelling of the glands being present in some cases. This was merely the *avant courier*, or, rather, the commencement, of the plague, which ravaged this town in the following year. And yet, it was stated, that the disease had been introduced into Marseilles by a ship that arrived in 1720; although, in addition to the preceding facts, there had been several cases of actual plague in the town before its arrival. But this is only one of the thousand and odd "fairy tales" of the contagionists.* The plague extended to Toulon, Aix, Arles, and other places and committed great ravages; 87,659 having perished in Provence, out of a population of 247,899. During the prevalence of the disease, all social affections became extinct. While the plague was prevailing in these places, there was a very marked increase in the rate of mortality from ordinary diseases, or fevers, in Loddon, Amsterdam, Vienna, and other towns, as, also, in America. Webster informs us,

* For the other facts connected with this outbreak, see Part 1, Chapter 1, p. 58.

that a letter from Thomas Hacket, of Duck Creek, and dated April 10th, 1720, states, that a mortality prevailed in that place, which exceeded that in London in 1665. The nature of the disease is not stated, but it was probably a pestilential form of fever. Another circumstance illustrative of the connection in the rise and progress of the diseases of Europe and of America is worthy of note. The true plague broke out in Vienna in 1722, and, in the following year, a "burning ague" prevailed in America, and was as fatal as any disease previously known. Intermittents were also very common in England at this time, together with inflammatory fevers, which were unusually fatal. From this time until 1727, malignant fevers prevailed all over Europe and America; as, also, small-pox, of which Louis, King of Spain, and the Duchess of Bedford died. It was in this year, that inoculation was first practised on criminals, having been employed, in 1713, at Constantinople.

In 1727, mania was epidemic in Spain, and was followed, the next year, by influenza—*un catarro sufocativo*, as it was termed. This influenza extended over the greater part of Europe, including England and Ireland; it also reached America. Horses were attacked at the same time. To this succeeded miliary fever in France, and in other parts of Europe malignant diseases, of various kinds, which continued to prevail until 1735. Canine madness was epidemic, in 1734, in Europe; and, in the following year, plague appeared in Egypt, and pestilential diseases in Tangiers, Aleppo, Smyrna, and all parts of Europe In Grand Cairo, 100,000 died from plague in 1736—7,000 being buried daily for some days. This pestilential period continued for ten years.

In this or the previous year appeared, in America, what has been termed the "throat distemper" of a malignant and fatal form. It principally attacked children, and carried them off in three days. After appearing at Kingston, in New Hampshire, in May, the epidemic continued to prevail during that and part of the next year, gradually travelling southward, and "almost stripping the country of children, who were attacked in the most sequestered situations. It was literally the *plague among children*." This disease was no doubt the Angina maligna, or *morbus strangulatorius*, which had prevailed in Italy and in Spain in the previous century. It appeared in London in 1739, and is described by Fothergill, being the first English record of the disease. In the following year dysentery was very prevalent in England and other places, and caused great and incredible mortality, as, also, in Germany; while the plague broke out at Tobolsk, in Siberia, having been preceded by murrain. In July of this year —1741—spotted fever broke out in England, and caused great mortality among the poor. Short states, that deaths were so frequent, and became so familiar, that it was no terror. In Ireland, fluxes and malignant fevers swept off multitudes of all sorts, so that whole villages were laid waste; parishes were almost desolate; and the dead were eaten in the fields by dogs, for the want of people to bury them. It is computed that, at least, 80,000 perished that year in Ireland from disease. In France, the ulcerated sore throat was epidemic, as, also, in America, but it did not appear in England until the following year (1742): it had, however, been preceded by its congener —scarlet fever. This disease, with the ulcerated sore throat, were the principal and most fatal epidemics at this period. In one town, on Long Island, only two children under the age of twelve years survived. While these events were passing in the West, plague was raging in Egypt; 10,000 victims, as some writers assert, having been carried off in a single day. In the next year, Sicily and Italy were visited by the plague, in its severest form; Messina having lost 46,000 out of a population of only 72,000. In those parts of Italy, not visited by the plague, dysentery prevailed. In 1744, catarrh spread over Europe: it was at Rome in February, and at London in March, and killed, says Short, more than any catarrh since 1665.

In 1745, an epizootic sprung up, having commenced in Turkey, whence it gradually spread over the whole of Europe. It prevailed in England for 12 years, in spite of the pole-axe, and all the other measures that were adopted for its extinction. In 1746, no less than 80,000 cattle were killed—at a cost of 135,000*l*.—in order to prevent the spread of the disease. During the height of the epidemic 7,000 animals were slaughtered each month, yet the disease continued to rage until 1758; a general thanksgiving having been ordered in 1759 to celebrate its cessation. No account has been left of the total loss; but Lincolnshire is reported to have lost 100,000 in the second year of the visitation; and Nottinghamshire and Cheshire 40,000 and 30,000 respectively, during six months only, in the following year, the third of the outbreak. The ravages of the disease were as great on the Continent, 200,000 cattle having perished in Holland; while in Belgium so few cattle were left, that it was feared they would become extinct.* The murrain continued to prevail on the Continent for a longer period than in England; or, else, there must have been fresh outbreaks. Thus from 1768 to 1771, Holland is reported to have lost 395,000 cattle, so that few were left alive at the end of this period. It prevailed again in France from

* In Madrid, a pestilence among dogs swept away multitudes, 900 having died in one day; in Genoa, the poultry perished at the same time.

1771 to 1776, after having subsided in 1746. It also existed in Schleswig-Holstein and Denmark, from 1774 to 1781, during which period it destroyed 150,000 cattle. Austria, it is stated, continued to suffer from the plague for 30 years, without intermission; but there were only slight returns of the murrain in England subsequently to the cessation of the last visitation in 1768. There was a slight outbreak in Hampshire and in Banffshire in 1769; and in Suffolk in 1774; but the disease did not spread beyond these localities on these occasions. This is precisely the result that has been observed with the cattle plague of the present day, an outbreak having occurred in Yorkshire in 1872, five years after its total cessation in 1867. But the disease did not spread in the present instance any more than in the former, although we are told, that the infection of cattle plague can be carried, from John O'Groats to the Land's End, by inanimate objects, and from farm to farm, by pigeons, starlings, dogs, rats, &c., as well as the wind.* This, however, is a digression. As no general, or epidemic, murrain appeared after that of 1745, we may conclude, that the epizootic pestilential epoch, we have been considering, and which had continued during all historical periods, then terminated, at least in Europe. With man, the pestilential principle ceased to act about the same time; for although there were a few isolated outbreaks of plague in Europe, after this, they were entirely local. The pestilential area of plague, since then, has been confined to Turkey, Egypt, and the adjoining territories; notwithstanding the great and constant communication and traffic that exists, in the present day, between these

* For an account of the outbreak in Yorkshire; and for the proofs of its spontaneous origin, see Part I. p. 352. Chapter Epizootics.

countries and Europe – a sure proof that this disease is not contagious, and that it cannot be propagated by either animate or inanimate objects.

With physical diseases, mental ones also subsided; and the mists which had so long obscured the human intellect —particularly during the dark and middle ages—became suddenly removed. Men then threw off the trammels of superstition; burst asunder the chains, with which they had been bound, by an ambitious, cunning, and ignorant priesthood; and proclaimed, with a voice of thunder, that shook the world—that which had been engraved, in letters of blood, on the foundation stone of Christianity—liberty of conscience; and, with religious liberty, as its natural sequence, civil liberty; for there is no despotism like priestly despotism; and there is no cruelty equal to that which has been perpetrated, in the false and outraged name of religion—that religion, which was ushered into the world with the cry of "peace on earth, and good-will towards men." It was then, also, that the glorious galaxy of intellectual stars made their appearance—Galileo, Kepler, Newton, Des Cartes, Bacon, Locke, Shakespeare, Milton, Dante, Molière, Corneille, Goethe; and a host of philosophical and scientific writers, to whom we are indebted for those great discoveries that have enriched the present century.

Independently of plague, other diseases disappeared about the same time; while the frequency and fatality of those that remained gradually became less and less. The leprosy, although so general in Europe, in the Middle Ages, as to cause leper houses to be established in every country, and in almost every town, began to decline in the 17th century, and had disappeared, with the exception of isolated cases, at the commencement of the 19th century. The sweating sickness, which was unknown before 1430, disappeared in England in 1679; and the spotted fever, which had been the almost invariable accompaniment of the plague, ceased to be observed soon after the disappearance of the latter. Even ordinary fever gradually subsided, and to a remarkable extent. From 1700 to 1710, the mortality from fever, in London, was 30,467: but from 1790 to 1800 the deaths only amounted to 17,169; while, from 1820 to 1830—immediately previous to the introduction of sanitary reform—the number had diminished to 9,000—being an average yearly mortality of 900.* Intermittent fever, also, which sometimes prevailed like a plague, assuming a malignant and fatal form, and which was epidemic in England, in the middle of the 18th century, ceased to prevail epidemically, and became, towards the end of the century, a mild and non-fatal disease. The subsidence of dysentery, the endemic of India, and which at one period, prevailed in England to as great an extent and in as severe a form, is still more marked. In the 17th century, the number of deaths in London, under the title of *bloody flux*, and *griping in the guts*, appear never to have been less than 1,000; and, some years, to have exceeded 4,000; and, for twenty-five years together, from 1667 to 1692, they every year amounted to above 2,000. But the numbers, after this, declined so regularly and rapidly that, in 1799, the deaths, from this disease, only amounted to thirteen! † We observe the same remarkable results with respect to the mortality from children. Between the years 1728-38, when the ages were first set down in the Bills of Mortality, the burials of children under two years

* As these figures are taken from the Old Bills of Mortality, it it right to add, that they only include those buried according to the rites of the Church of England. Still, for the purposes of comparison, they are equally valuable.

† See the Statistical Table in Part I, p. 119.

of age, amounted, on the average, to 10,000. In the next decade, they had diminished to 9,000; in the following, to 7,800; and, between 1700 and 1800, the number was little more than 6,000 annually. The mortality of the children in the Foundling Hospital—under the age of twelve months, and who are all put out to nurse—diminished, during the last half of the 18th century, in the proportion of 12 to 7. As diseases diminished, longevity increased in an inverse ratio. In the Parliamentary returns for 1811, it is stated, that the annual mortality in England, in 1700, was 1 in 25; in 1750, 1 in 21; and, in 1800, and the four preceding years, 1 in 36. In Manchester, according to Dr. Perceval, the rate of mortality, in 1759, was 1 in 25.7 ; in 1770, 1 in 28; and in 1811, only 1 in 74. The result will be still more striking if we carry the comparison back one or two centuries. This has been done by M. Marc d'Epine, who has shown, that the probable duration of life at Geneva, in the 16th century, was rather less than 5 years; in the 17th century, it had risen to 11 years; at the beginning of the 18th, to 27 years; and at the end of this century, to 32 years.* M. Mallet also ascertained, that the mean duration of life in Geneva, in 1833, was nearly the double of that recorded two centuries before; or, as 40 to 21 years.† With these results before us, it is evident, that the epidemic pestilential epoch, which had existed for the previous twelve centuries, if not longer, terminated, in Europe, at the end of the last century. It has continued longer in Africa, in Asia Minor, and in Asia; but the same gradual decline is manifest there also, as shown by the long interval since there has been an outbreak of plague in these regions.

* The North American *Med. Chir. Rev.* Sept. 1861.

† See also Table A, in the Introduction, p. xi.

The cause of the variation has been pointed out in the first chapter of this work.*

As regards the other phenomena, or the aberrations in the material world, we shall find, on inquiry, that atmospherical vicissitudes, although still great, in this century, were not so frequent as before; while they gradually declined, *pari passu*, with the morbid effects in the organic kingdom, towards the end of this century. In 1703, occurred the "great storm," as it was termed. De Foe calls it, "the greatest, the longest in duration, and the widest in extent, of all the tempests and storms that history gives any account of, since the beginning of time." He states, that it traversed England, Denmark, and the Baltic, to lose itself in the Arctic regions. Six line-of-battle ships, belonging to the squadron of Sir Cloudesley Shovel, were sunk in the Downs, with the loss of 1,500 men. In the Thames, the tide rushed up with a velocity similar to "the bore" in the Ganges: an immense number of vessels were lost, and the damage done was estimated at two millions. The winter of 1716 was excessively severe: a fair was held on the Thames, and the rivers in Italy were covered with ice. This unusual severity in the weather was experienced in America, *the following year;* which was also remarkable for "prodigious storms of snow." The same effects were observed in 1740-41, the severe weather in America being a year later than in Europe. In 1750-51, great cold was experienced in Turkey, together with a heavy fall of snow; in consequence of which, it was predicted, that there would be a visitation of plague —a prediction that was unfortunately verified, 200,000 persons having been cut off by this disease before the end

* There have been some recent outbreaks of plague, it is true, but these belong, as will be shown hereafter, to the present, *not* the past, pestilential epoch.

of the year. On the 7th March, 1751, a tempest at Nantes, France, destroyed 66 ships and 300 lives; and, on the 8th December, another occurred at Cadiz, by which 100 sail were lost. The winter of 1756-7 was, also, excessively severe in Syria: olive trees, that had withstood the weather for fifty years, being destroyed, while thousands of people perished with the cold. In the following summer, there was a drought, the crops failed, and the famine was so severe, that parents devoured their own children. The summer of 1763 was remarkable for hailstorms, one of which entirely destroyed thirty-six villages in France—the hailstones being from three to ten inches in circumference. In the following year, the degree of cold in England was unparalleled—the mercury having fallen to 7° Fah.; and, in some places, actually within the bulb. The winter of 1766-7 was also very severe in Europe and America; and snow lay in the streets of Naples to the depth of two inches. No remarkable vicissitudes occurred after this, or during the remainder of this century.

Cosmical phenomena. These, like the atmospherical vicissitudes, were not only less frequent, but, with one exception, less severe than in the previous centuries. In 1755, a concussion occurred, that has been memorable in the history of such phenomena. The centre of the concussion was Lisbon, which was nearly ruined, 12,000 houses having been overturned, and many lives sacrificed; while shocks were felt at considerable distances from this central focus—east, west, north, and south; being more severe, however, in the west, and in the south, than in the other directions. Thus, in the South of Spain and of France, and on the north-west portion of Africa, the shock was felt severely, as, also, at Funchal; near to Morocco, a mountain opened and swallowed up a village, with 8,000 or 10,000 people. In Italy, Switzerland, Norway, Sweden, and England, the shocks were only slight, and particularly in the last-named countries; but a rather severe shock was felt in America—in New England, New York, Annapolis, and Halifax. The direction of the shock was from N.E. to S.W., and its extension is stated to have been about 800 miles, the centre being in lat. 43° N. Van Hoff states, that a ship felt the shock 50 leagues from Lisbon, and on November 7th, six days after the first great catastrophe, another shock occurred, which was felt on board a ship 60 leagues from the coast of Portugal: and, in another ship, 72 miles east of Cape Ann. We have thus proof, that the volcanic band of the Mediterranean extends beneath the waters of the ocean to the northern portion of the continent of America—a connection, that has been previously pointed out.* Independently of the concussions, three waves were produced at Lisbon from 15 to 40 feet high, each wave having been preceded by a shock, while the bed of the Tagus became dry for a short time. At Tangier, also, the sea rose 50 feet; at Gibraltar, 7 feet; in the lakes of Geneva, Zurich, and Constance, 6, 8, and 12, feet; but on the coasts of England, Ireland, and Scotland, the rise was only 12 or 18 inches. There were other effects well deserving of consideration, on the present occasion. It is stated, that a great many meteorological phenomena were observed, both in Spain and in Portugal, for a month before the concussion; and a few minutes previously to the shock, a thick vapour covered the river Aar, the water of which appeared to boil. At Tetuan, the water in the river Chico was coloured red—a phenomenon that is frequently

* In 1775, a bed of oysters, in the harbour of Wellfleet, America, 20 miles from Boston, which, previously, had given an abundant supply, perished: and Webster states, that they have never since grown in that spot.

observed when no concussion has been felt. It is also worthy of remark, that the smoke, or vapour, disappeared from the duct of Vesuvius at the moment of the concussion.

From this time, concussions of the earth gradually declined, both in intensity and frequency, in Europe and in Asia. They did not disappear as soon or as completely as the pestilence that had accompanied them, nor was it necessary that they should do so, in order to support the present hypothesis. As these phenomena do not stand in the relation of cause and effect; but are merely common effects of a common cause, the one set of phenomena might continue for a longer period than the other, as was actually the case; the cause being still in existence. That the cause productive of these phenomena is still in existence, we know from the increased activity of Vesuvius at this period: while it is precisely to this circumstance, as has been already pointed out, that the diminution and cessation of the other phenomena are to be ascribed. All that it was necessary to do, on the present occasion, was to show, that pestilences in the animal creation, or, at least, those general pestilences, or epidemics, which traverse certain portions of the terrestrial sphere, are always preceded, accompanied, or followed, by great and unusual atmospherical vicissitudes, and by concussions of the earth, along some portion of the route taken by these diseases. We have seen that this was actually the case, during the whole time of the prevalence of the plague in Europe; while the intensity of the one set of phenomena has borne an exact ratio with that of the other. As this result was observed, not on one or two occasions only, but invariably for many centuries—nearly 2,000 years—these various phenomena must be connected together by a link so strong, that neither sophistry nor scepticism will be able to break it. It is, in fact, the *experimentum crucis*—the last link in the chain of causation that has been formed, in order to prove, that epidemic diseases, and abnormal atmospherical vicissitudes, are, like terrestrial concussions, the effect of volcanic action. As this was evidently the case with the pestilence that prevailed during the last pestilential epoch, it only remains to ascertain, whether the same result has been observed since then, or at the present epoch. This will form the subject of the next chapter.

CHAPTER V.

PESTILENTIAL EPOCH OF THE 19TH CENTURY.

As will be apparent, from the facts and arguments previously advanced, this epoch commenced in Asia, in 1817, and in Europe, in 1830, with the advent of the epidemic cholera—an entirely new disease; for although a somewhat similar affection prevailed at the commencement of the last pestilential epoch, it had not been observed since. As the course and progress of this *nova pestis* has been already given, and as its history is now so well known, it will not be necessary to enter into these particulars on the present occasion. Independently of cholera, other new diseases have sprung up simultaneously. This is the case with diarrhœa, which is as new a disease as the epidemic cholera, dysentery having been the form of bowel complaint that prevailed previously in this country—an affection which, although frequently confounded with diarrhœa, is as distinct from it as the epidemic cholera is from the ordinary, or indigenous, cholera. The first time that diarrhœa is mentioned, in the London Bills of Mortality, was in 1819, when two deaths from this disease were recorded. Between this date and 1830, there were 145 more, 31 of these cases having occurred in 1829. Since then, nearly all the deaths, registered under the head, " bowel complaints," have arisen from diarrhœa, not dysentery. Thus, of 30,403 deaths from this cause in London, during the decade 1860-70, the number from dysentery was only 1,018. Now it is somewhat curious, that this disease should have sprung up in London, and, in all probability, in other parts of England, about the same time as the epidemic cholera in India; thus showing that the pestilential epoch actually commenced, in the two countries, simultaneously.

Typhoid fever is another new disease, having been first recognised in France, and described by M. Bretonneau, in 1813. It did not appear in England until 1827 or in Scotland until 1848; but it was recognised in America in 1833, and was described by Dr. Jackson, in a communication to the Massachusetts Society, in 1838. Strictly speaking, we can hardly call this a new disease: it is rather a new form of an old and common disease, viz., intermittent fever. According to M. Boudin, as already mentioned in the introductory remarks, "the drying (or drainage) of the soil or its conversion into a lake,* while causing the disappearance or diminution of *paludal* diseases, appears to predispose the organization to a new pathological condition, according to the locality, and in which phthisis and typhoid fever play a prominent part." That intermittents have prevailed to an unusual extent, and in a more severe form than previously, since the advent of the epidemic cholera, is well known, as was more particularly observed in India, Austria and Spain. In the last-named country, two-thirds of the population were attacked in the provinces of Murcia and Andalusia, on the subsidence of the cholera; while the disease proved rebellious to all the ordinary modes of treatment. But in other situations, where the soil is drier, either naturally or from artificial causes, typhoid fever has made its appearance. Whether, therefore, we call this disease a new one, or a new form of intermittent fever, matters not: its prevalence of late years, and to so great an extent, shows, that the causes pro-

* For an explanation of this apparent anomaly, vide *Causation and Prevention of Disease*; and the Laws regulating the extrication of Malaria from the surface.

ductive of disease are in operation now to a greater extent than before. But whatever doubts may exist as regards typhoid fever, there can be none respecting diphtheria, which is an entirely different affection to any previously described; and did not make its appearance in England until 1855. It has continued to prevail, more or less, every year since; the deaths having varied from 186, in 1855, to 9,567, in 1859—the number up to 1870, never having been under 2,000, with the exception of the first three years.

In addition to the advent of new diseases, we have proof of the commencement of a new pestilential epoch by the return of old ones; their frequency and intensity. This is the case with carbuncles and boils, which have always been the accompaniment of pestilence, and which appeared, epidemically, between 1847 and -55. In a Paper read at the Medical Society of London, March 10th, 1855, the writer, Mr. Hunt, traced the epidemic to the year 1847; and showed that it had existed in all parts of the world for about eight years. The deaths in London, from carbuncle, during this period, increased gradually from 5 and 6, annually, to 91 in 1854.* Precisely the same result has been observed with another disease—small-pox—which declined so rapidly, during the first part of this century, that its final extinction was confidently expected. We shall of course be told, that this diminution is to be referred, wholly and solely, to vaccination; and we should be bound to adopt this conclusion, if we looked at the question by itself, and without reference to other facts.

* Mr. Hunt also called attention to the fact—now universally admitted and acted on—of the *atonic* and *asthenic* condition of nearly all diseases. Previously to 1830, an inflammatory diathesis characterized the majority of diseases—a state that demanded depletion as imperatively as the present type of diseases forbids it.

When, however, we find, that all other diseases declined at the same time, and as rapidly, we are naturally led to inquire, whether the same general cause may not have produced the same result with small-pox? That this disease had actually began to decline, and to a considerable extent, before the introduction of vaccination is undoubted; although the diminution was not, and could not be, so great as in other diseases,—at least not in England—in consequence of the introduction of inoculation in 1722,—many of these cases assuming a severe form. Still, if we compare the mortality from this disease, during the latter part of the last century, with that which occurred at former periods, and in other countries, a great and striking difference will be perceived. Small-pox broke out in Iceland, in 1241-42, and between this date and 1707 there were 18 visitations—being, on the average, one visitation every 15½ years. The majority of these were alike general and fatal: 18,000, out of a population of only 50,000, having perished in the last outbreak. No other invasion occurred until 1785—an interval of 78 years,—while the mortality was insignificant, when compared with the previous outbreaks—1,425 only having died.* Again; a severe visitation of small-pox occurred in Mexico, soon after its conquest, and carried off, it is said, 3½ millions of its inhabitants. We have no accurate accounts of the intermediate outbreaks: but in 1779, there were, in the capital, 30,000 attacked, of which number 9,000 died—being a ratio of 30 per cent. In a subsequent outbreak in 1797, the deaths only amounted to 4,451, and the attacks to 24,516—the ratio of mortality thus amounting to 18 per cent.: very little more than half that of the previous visitation.† We are also in-

* *Travels in Iceland.* By Sir G. M'Kensie. Ed. 1811.

† Oppenheim's *Zeitschr.* Vol. 34.

formed by Ring, that the capital of Thibet once remained, for three years, without an inhabitant, from the ravages of small-pox; and it is said, that 20,000 died in Paris, during a visitation of this disease in 1720. But we never hear of such results as these, during the latter half of the 18th century. On the contrary, we have proof, that this epidemic had assumed a mild form, even in England, long before the introduction of vaccination. Dr. Wagstaffe, who published some observations in 1722, on the prevalence of small-pox in children, states: "that the mortality did not exceed 1 per cent. (of the cases)." Isaac Massing, also, apothecary to Christ's Hospital, in a pamphlet published the following year, remarks; that "not one out of 50 (cases) had died of small-pox, in that institution, during the previous 20 years; and only one during the previous nine years, although some hundreds have deen down of it." Jenner, also, speaks of a mild form of small-pox, which existed in his day; so mild, in fact, that, in hundreds of cases, there was no death; while it was not regarded by the common people with any dread. With such a diminution in the frequency and fatality of small-pox, there can be no reason why that diminution should not have continued during the first part of this century, the same as we have observed was the case with all other diseases, even had vaccination not been introduced. That vaccination has been beneficial by superseding inoculation, and, also, by rendering the attacks of small-pox milder than with the unvaccinated, is undoubted; but this is all we can allow. To assert, as the advocates of vaccination do, that the exemption of England from any visitation of small-pox, from 1796 to 1825, is due entirely to vaccination, is absurd and paradoxical; in this instance, as in so many others, a coincidence has been mistaken for the cause. Herr Kolb, an eminent German statistician, in a recent pamphlet on the vaccination question, remarks :— "When the disappearance of epidemic small-pox, about the time of the introduction of vaccination, is brought under notice, we observe the gradual diminution of the destructive power of the earlier period, and a more restricted range in the latter outbreaks. This was immediately taken as a proof of the infallibility of the new dogma. Yet an unbiassed and intelligent criticism cannot avoid perceiving, that it is *impossible*, that the disappearance of the epidemic small-pox, at that early period, can have been due to the newly introduced panacea. Small-pox was already on the decline in proportion as inoculation became less general! Thus, in 1802, there were in all Germany not more than 300,000 vaccinated persons, in a population of 30,000,000; whilst in England, in 1807, according to a report of the College of Physicians, about 1½ per cent. or a little more than 164,000, were protected. Allowing that this minority were rejoicing in their absolute and life-long protection, how came it to pass, that the same immunity was granted to the remaining millions of unvaccinated people? It is clear, that whilst so few were vaccinated, the cow-pox could not have formed the only possible safeguard against the spread of infection. Very striking is the experience of Sweden. In 1800, the small-pox mortality was 51 in 10,000 of population. In 1801, the number of vaccinated was only 8,000, yet the mortality fell to 24. In 1802 it fell to 7. But, instead of drawing the very natural conclusion, that small-pox was on the decline, the newly vaccinated 8,000 were credited with spreading their salvation over the remaining 2,500,000 of inhabitants! And these are vaccination statistics!" If, indeed, the non-prevalence of small-pox, at the commencement of the present century, is to be ascribed to vaccination, how are we to account for the late visitations of this disease? Has the practice of vaccination been discontinued of late years, or, has the vaccine lymph become deteriorated in quality? Neither of these results would seem to have occurred. Vaccination was rendered compulsory in England, in 1853; while Mr. Simon stated, in his examination before the Vaccine Committee, that about 97 per cent. of the population of London was then protected, either by vaccination or by previous attacks of small-pox. Nevertheless, there have been three visitations of small-pox since then, each being more severe than the preceding. This will be rendered evident by a reference to the following figures:—

Date.		Deaths from Small-pox.
Epidemic of	1857-58-59	14,244
"	1863-64-65	20,059
"	1870-71-72	44,840

Increase of population from 1st to 2nd epidemic	7 per cent.
Increase of Small-pox in same period ...	nearly 50 per cent.
Increase of population from 2nd to 3rd epidemic	10 per cent.
Increase of Small-pox in the same period ...	120 per cent.

Deaths from Small-pox in the first 10 years after the enforcement of Vaccination—1854 to 1863 ...	33,515
In the second 10 years—1864 to 1873	70,458*

Nor can we infer, that the vaccine lymph has become deteriorated in quality, as fresh matter has been obtained, from time to time, at the original source. More care, in fact, has been taken, of late years, to obtain a pure supply of lymph than formerly. To what, then, are we to refer this apparent anomaly, this increase of small-pox with the increase of vaccination? The question is too important a one to be left without a solution, if one can be obtained.

The task is not so difficult as it may at first sight appear. Mr. Marson, Surgeon to the Small-pox Hos-

* From *Vital Statistics*, No. 1. A letter to the Rt. Hon. G. Sclater-Booth, M,P., by C. T. Pearce, M.R.C.S., February, 1877.

pital, states, that cases of small-pox, after vaccination, were rare at the commencement of this century; but, in 1819, there were 19 cases admitted into the Small-pox Hospital, London. In 1825, 147 were admitted. From this period, cases of small-pox, after vaccination, have kept gradually increasing in numbers, until they now amount to four-fifths of the admissions into the small-pox hospitals. In one institution, the ratio of vaccinated cases to the whole of the admissions of small-pox patients, from 1835 to -51, was 53 per cent. In the epidemic of 1851-2, it was 66.7 per cent; in that of 1854, -5, and -6, it amounted to 71.2; in the next—that of 1859-60—to 72; in the epidemic of 1866 to 81.1, and in 1868, to 84 per cent.* It is thus apparent, that there were few cases of small-pox, after vaccination, before 1825; while it has been since 1835, that the ratio of vaccinated cases has gone on increasing so rapidly. With the facts previously adduced, the cause will be sufficiently apparent. A new epoch—a pestilential epoch—commenced in 1817 in India; and, in this country, in 1819, if we reckon from the advent of diarrhœa; but in 1830, if we take the arrival of the epidemic cholera as the point of departure. Now it is precisely at the same period, that the first visitation of small-pox occurred in England, in this century—viz., in 1825; while it has returned regularly, and at short intervals, from that date to the present. In London, there have been *nine* visitations in 31 years—viz., 1840-1, 1844-5, 1847-8, 1851-2, 1854-5, 1859-60, 1862-4, 1866-7, and 1870-1; while the last visitation was the most severe of any. "We," remarks the Editor of the *Lancet* (Dec. 23, 1871), "are about to make a statement which, if it were not based upon stubborn, undeniable facts, at this moment before us, we should cer-

* Reports of the Highgate Small-pox Hospital for 1866 and -68.

tainly not believe ourselves nor ask credence for in our pages, so lamentable is it, and so discreditable to the intelligence of the people and rulers of this country. In the year 1870, there were registered, in the seventeen principal cities and towns of England, 1,259 deaths from small-pox; in the year just closed, there have fallen victims to that disease, in the same towns, no less than 13,174 persons. The proportion of fatal cases to the population of the seventeen towns, taken in the aggregate, was 18 per 10,000; the ratio in London was 24, in Norwich 30, in Liverpool 39, in Wolverhampton 41, in Newcastle-on-Tyne 54, and in Sunderland 86. The highest small-pox mortality in London, during the 31 years, 1840-70, was in 1863, when 2,012 fatal cases were registered. Last year, they rose to the unprecedented number of 7,876, whereof 2,400 occurred in the first, 3,241 in the second, 1,255 in the third, and 980 in the fourth quarters." To those who expected that vaccination would extinguish small-pox, such surprise is natural; but to others, it cannot be considered as singular, that this disease should have returned, and should have increased, in frequency and in intensity, at this period, the same as other epidemics. That small-pox is a regular epidemic, not a disease *sui generis*, or produced by a different cause, is undoubted. It obeys the same laws as all other epidemics; it appears and re-appears at certain intervals, and has, like them, its regular rise and decline. More than this, it is evidently produced by the same cause as other pestilences. It sprang up, in Europe at least, together with the plague in the middle of the 6th century, and raged, in common with this disease, for ten centuries—the intensity of the one being in exact ratio with that of the other—while both began to decline and to disappear at nearly the same time. In the same way, it has re-appeared, in an epidemic form, at the commencement of the present pestilential epoch; has returned at nearly the same fixed periods as before; and has gradually increased, in intensity and extent, from 1825 to the present time. Mr. Simon, in his answer to the Chairman of the Vaccination Committee, said: "There appears, in the statistics, absolutely no connexion whatever between the increase or decrease of small-pox, and the decrease or increase of other diseases!"* What there may be in the statistics, I know not; but this I know, that if there be one fact better attested than another, in the medical history of diseases, it is, that all diseases—both epidemic and endemic—more particularly at the same epoch, are intimately connected together; not only prevailing simultaneously, and in the same intensity, but frequently running the one into the other. A reference to the facts contained in the previous chapters will prove this. Small-pox, in fact, is only one link in the chain of effects, that has been lately forged, by an invisible and unknown agent, and all the efforts of man to destroy it, or to separate it from the others, will be utterly futile. More than this, we may infer, without any risk of error, that it will continue to return, in spite of vaccination, as long as the present pestilential epoch lasts, no matter how long that may be. It would appear, therefore, to be mere fatuity, on the part of certain writers, to maintain, that vaccination ought, and will, if universally adopted, banish this scourge from the earth. In his examination before the Committee, just referred to, Mr. Simon observed: "I believe that for most persons, I would even say, for an overwhelming majority of persons, well vaccinated in infancy, that vaccination is a security for life, even against *an attack* of small-pox." † By what process of reasoning, the witness arrived at this conclusion, it is difficult to un-

* Report p. 167, Qn. 2990. † *Loc. cit.*, p. 173. Qn. 3041.

derstand : we might have inferred, if vaccination does not prevent attacks in four-fifths of the patients admitted, at present, into the small-pox hospitals, that the same operation, however well performed, cannot produce a much greater effect hereafter. Nor will re-vaccination—the last refuge of those who maintain that small-pox can be stamped out—produce any better result. It is stated, in one of the Reports of the Academy of Medicine, Paris, that an outbreak of small-pox occurred in a regiment, in which 437 of the men had been recently re-vaccinated; while another regiment, in which no re-vaccination had taken place, entirely escaped. In the British Army all the recruits are re-vaccinated; yet the mortality among this class of men is, according to Mr. Gibbs, the same as with the civil population—viz., 84 per million.* This result is the more singular, from the fact, that the liability to small-pox diminishes with age, and that only adults are included in the army returns. Dr. Stramm, Medical Staff Officer, in the Prussian Army, states, in a pamphlet on the subject, that he had been vaccinated and *twice re-vaccinated*, and yet was attacked with small-pox in its most virulent, or confluent, form. All that vaccination can do is to mitigate the attack, and to lessen the fatality of small-pox—an advantage that may be nullified hereafter, to a greater or lesser extent, should this disease return with increased intensity. That it will do so, we may infer, not only from the fact that this epidemic has been gradually increasing in intensity, since 1825, but, also, because all other diseases, and particularly the epidemic cholera, have also become more and more malignant during the same period. As such, the beneficial effect of vaccination, we may conclude, will gradually become less and less—an inference that would appear to be confirmed by the follow-

* *Vaccination Committee*, Qns. 1597—1607—1677.

ing facts. At the Hampstead Hospital, in 1871, the ratio of mortality, with the vaccinated cases, was 8.95 per cent., and, with the unvaccinated, 41.91 per cent. But in the General Hospital, Calcutta, in 1850, the ratio, with the vaccinated cases, was 24.24 per cent., and, with the unvaccinated, 40 per cent.—a difference that may be ascribed, wholly and solely, to a difference in the intensity of the disease in England and in India. A similar result has been observed even in England under analogous circumstances. In that form of small-pox, termed *Corymbose* (from *corymbus*, a bunch of ivy berries)—a rare and fatal form of the disease—104 cases were admitted into the London Fever Hospital in the course of 30 years. Of the unvaccinated—29 in number—13 died, or 44 per cent.; and of the vaccinated—74 in number—32 died, or 41 per cent.; 2, who died of superadded disease, having been deducted.* There was thus only a trifling difference between the vaccinated and the unvaccinated, in these instances. These facts have an important bearing on the value of vaccination; and on the question of compulsory vaccination, which will have to be abandoned hereafter, as soon as it is found, that this operation has no influence in preventing returns of the disease; and, what is of more consequence, that the ratio of mortality between the vaccinated and the unvaccinated cases is insignificant. It may, probably, have to be abandoned before this, and for other reasons.†

Typhus fever, the connection of which with plague has been pointed out in the first part of this work, has also reappeared: the fever that prevailed previously being of a

* *Reynold's System of Medicine.* Vol. I., p. 436.

† It was stated, in a Lecture by Mr. Hy. Lee, F.R.C.S., that the foulest of all diseases had been communicated to an entire village by means of vaccination!!—*Lancet*, June 12, 1875.

sthenic not an asthenic character, and requiring the very opposite mode of treatment. Scarlet fever, also, which, although not extinct, had become less frequent, and had assumed a milder form, again began to prevail epidemically, and to increase in frequency and intensity. There was no separate entry, in the old bills of mortality, for scarlet fever; but, as the total deaths from all kinds of fever, in London, from 1820 to 1830, were only 9,884, the number must have been insignificant. In the decennial period, 1860-70, the deaths from this fever alone amounted to 29,644. According to the returns of the Registrar-General, the ratio of mortality in London, in 1841, from scarlet fever, was 32 to 10,000 living. In the quinquenniem, 1859-63, it had increased to 115: while, in 1863, the ratio was 174, being five times more than in 1841. This vast increase in the prevalence, not only of scarlet fever but of ordinary fever, as, also, of bowel complaints, will be better exhibited in the following table.

TABLE E.—Total mortality from fever and bowel complaints, in London, in the following decennial periods :—

Years	Dysentery and Diarrhœa	Fever	Ditto Scarlet	Total Fever
1800 to -10	232	17,777	—	17,777
1810 to -20	276	10,637	—	10,637
1820 to -30	276	9,884	—	9,884
1830 to -40 *				
1840 to -50	17,382	20,335	19,000	30,434
1850 to -60	26,954	23,286	24,204	47,490
1860 to -70	30,403	26,283	29,644	55,927

As there was no registration for England before 1838, it is impossible to draw the same comparison as with

* As this was a transition period, when the old Bills of Mortality were discontinued, and the new mode of Registration adopted, the returns are imperfect, and have, therefore, not been added.

London; but a reference to the returns of the Registrar-General will show, that the great increase in all diseases, since that date, has not been confined to London.* These returns prove, without any other facts, that a new pestilential epoch commenced in 1830, in England, and that it has continued up to the present time. But it is not in bodily complaints only that this increase has occurred; the same result has been observed with mental maladies.

There are no records to which we can refer, in order to ascertain what the prevalence of insanity was, previously to the present pestilential epoch: it not having been necessary to register such cases then. We can, therefore, only refer to the statistics that have been published since the present system came into operation. According to the 28th Report of the Commissioners in Lunacy, there were 36,762 registered lunatics in England in 1859; but, on the 1st January, 1874, the number was 62,027—the annual increase for the ten previous years having been 1,723. Calculated on the population, the result is as follows. In 1859, the ratio of cases—lunatics and idiots—was 1.86; in 1869, it was 2.43; and, in 1874, it was 2.62 to every 1,000 living. Independently of ordinary cases of insanity, there have been other indications of an unusual prevalence of affections of the brain at this period. One of these is, the tendency to suicidal acts, which have been greatly on the increase of late years. From 1826 to 1830, the average yearly number of suicides in France was 1,739; whereas from 1861 to 1865 it was 4,661—nearly three times as many. That only a few of these cases are to be attributed to extraneous, or moral, causes is shown by the fact, that out of 4,595 suicides only 206 were in pecuniary

* The first time in which diarrhœa is mentioned, in the old Bills of Mortality, is in 1819, when two deaths were recorded.

difficulties; 159 completely ruined, and 464 who were destitute. On the other hand, there were 657 personsof ample fortune, and 2,000 who earned a handsome livelihood in trades or professions. In addition to this, a suicidal epidemic prevailed in France from 1861 to 1871. Homicide, murder, and other acts of violence, may also be referred, in a great many instances, to derangement in the functions of the brain. Hence the great increase, at the present epoch, of acts of violence.

As is apparent, from the facts contained in the previous chapter, religious monomanias have always prevailed at epidemic periods, and have become more or less general. These effects have only been observed to a slight extent at present; but they will recur hereafter, there can be no doubt, and to a greater extent. What is called Irvingism, was, at its commencement, a pure monomania; for not only did its founder die insane, but several of his disciples also became deranged, one of whom fell under my personal observation. In 1841-2, a singular epidemic of religious ecstacy spread among the inhabitants of the interior, or central parts, of Sweden; but I have no particulars as to its character or duration. The next account is of a more precise character. "Within the last twelve months," says one writer, "the unsettled state of popular feeling in Russia has generated several new so-called religions. The moujiks appear to be in a state of spiritual fermentation, which moves them to let off their surplus excitement by indulging in ritual extravagances. A quaint sect has been founded in the Don Government by a 'virgin prophetess,' named Xenia Kusmin, who has gathered round her twelve young and well-to-do men of the district. These converts to her creed call themselves her apostles, and, like herself, teach its tenets exclusively in song. Some of their articles of faith are as fantastic as their method of promulgating them. One prohibits the eating of meat; another abolishes marriage, and obedience to any ecclesiastical authority; a third proscribes the action of shaking hands with an acquaintance, which he denounces as a deadly sin. Xenia herself is stated to be a handsome young woman of five-and-twenty, gifted with a beautiful voice, and the knack of composing hymns innumerable. She lives in one and the same house with her twelve apostles, and spends her time chiefly in teaching them her compositions. Every now and then she invites extra-apostolic believers in her doctrines to evening entertainments, from which vodki and all other spirituous liquors are rigorously excluded. Her menu consists on these occasions of 'tea, sweets, and kisses.' One of her apostles, a pensioned soldier named Michael Kossenknow, has cast off wife and children for her sake; but, as he once made a pilgrimage to Jerusalem, he enjoys a local reputation as a sort of saint, and the orthodox, ecclesiastical, authorities do not dare to meddle with him. A religion which is made up of part-songs and vegetarianism, and which enjoins osculation, while it condemns the harmless hand-grip, is an odd kind of outgrowth which could scarcely have sprung up in any soil but that of Russia." * And a few days after (Aug. 2, 1879), the same journal stated :—" A new religion has sprung up in the United States, involving tremendous issues to the entire civilized world. It seems that a Presbyterian minister, named Groves, recently appeared at large in Texas, proclaiming that he had visions and revelations from on high. At first, he spoke an 'unintelligible jargon, in which deep pits, horrid beasts that devour one another, and green-coloured monkeys, constituted a lively back and fore ground.' The reverend gentleman soon

* *Daily Telegraph*, July 31, 1879.

discovered that a travesty of Ezekiel did not much impress the matter-of-fact Texans; whereupon he condescended to their weakness, and spake plainly, saying, that a mighty conflict between Catholicity and Protestantism was at hand, and that Europe and the United States were the horned beasts which would eat each other up. Upon this appalling 'platform' he soon made converts; among them a reverend brother, named Goodnight, with whose help Mr. Groves is now preparing a declaration of principles. The declaration, according to latest reports, is much wanted, since, in the absence of its authority, the two shepherds and their flock are not free from divergent opinions—above all, as to the identity of Antichrist. Mr. Groves believes that the Pope is Antichrist; Mr. Goodnight sees him in Mahomet; but, among the people, a growing conviction obtains that he is—General Grant. They even go so far as to sketch out a programme of the General's future operations in that capacity. Being elected President in 1880, he will, by a *coup d'état*, make himself military dictator and Emperor. Civil war will follow, but, the General's old luck serving him, he will beat down his enemies, defy law and religion, and then lead his victorious hosts against Europe. By what means the army is to cross the Atlantic does not appear, but, having crossed, thrones will crumble before it, and princes wait in the anteroom of its leader. Lastly, the General will proclaim himself the Supreme Being, and then be hurled to destruction by a greater Power preparatory to the Millennium." No other outbreak of the same kind has been recorded, as far as I am aware. It is a question, however, whether what is termed Ritualism, or Tractarianism, in England, may not be placed in the same category. This would appear to be the opinion of many persons, and, among others, of the following writer:—"Feeling convinced, that the Church of England possesses in her doctrine 'all things necessary for salvation,' that 'her yoke is easy and her burden light,' the *aberration* (for it can be called by no other term) *of the Tractarian is something strange and inexplicable.* When we consider, that a number of men, who were at first united for the sake of defending the Church of England, have, after years of study, arrived at *a state of morbid feeling, which only aims at her destruction,* we are almost tempted to cry out with Festus, 'Much learning hath made them mad.'"—(*Times*, October 11th, 1845.) No less singular is the fact, that several of those who have now joined the Church of Rome, or have become ultra-Ritualists, were, previously, the loudest in their denunciations of the doctrines and the practices of Popery. Either, therefore, these men were incapable of drawing correct conclusions formerly, or, else, they are unable to do so now—*l'un ou l'autre*—unless it be inferred, that they were hypocrites formerly. That men, who conscientiously believe, that the Church of Rome is the true Church, should join her communion is a natural and legitimate result. But that others, who have arrived at precisely the same conclusion, should continue to minister in a Church, which is anathematized by Rome, and which, on the other hand, considers the Romish to be a false and idolatrous Church; "who still ate the bread of the Protestant Establishment, while turning heaven and earth, and, one was tempted to think, some places under the earth, to overthrow it; who, from behind the lofty state-erected battlements, that were professedly built to oppose Popery, shot their envenomed arrows against the Protestantism they *had sworn to uphold*," * is a phenomenon

* Speech of the Rev. Dr. Aveling, at the Meeting of the Congregational Union of England and Wales, 1876.—The *Times*, October 11, 1876.

that was reserved for the 19th century to witness. So extraordinary has this movement appeared, that it has been ascribed, both by its advocates and by its opponents, to supernatural causes. "The rapidity and extent of its diffusion," observes one writer, "suggests—indeed forces on us—the idea of some supernatural influence, or *spirit*, having been at work in promoting it. . . . . Dr. Pusey (sad that such a man should be identified with such a system) has himself strikingly sketched this its rapidity of diffusion; the wonder of its human originators at the fact, and their conviction of some higher power assisting it." * Dr. Pusey remarks:—"From the very first, these views spread with a rapidity that startled us. The light seemed to spread like watch-fires from mountain-top to top: each who received it carrying it on to another, so that they who struck the first faint spark knew not how or to whom it was borne onward. And now, it has been reflected from hill-top to valley; has penetrated into recesses; abroad, at home, within, without, in palace, in cottage." On the other hand, Archbishop Sumner, in his episcopal charge, in 1841, while Bishop of Chester, ascribed the Tractarian heresy to "*a spirit of evil*, inspiring its human propagators;" and Archdeacon Hare, referring to the same movement, remarked:—"There is *a lying spirit* stalking through our Church; and even taking possession of some minds, that would otherwise be amongst its pillars and noblest ornaments." † If, however, this heresy has been produced by natural causes, there is no occasion to look to supernatural ones for its origin and spread: its characteristics being precisely those of all monomanias. As the causes productive of general,

* *Horæ Apocalypticæ.* By the Rev. E. B. Elliott, A.M., 6th Ed. Vol. 3, p. 526.

† In Appendix to *Mission of the Comforter.*

or epidemic, monomanias are evidently external, not internal, numbers would, of course, be affected at the same time, and to an extent varying with that of the operating cause. Hence it is, that one suicidal act is frequently followed by others; and with persons who, previously, manifested no morbid state of mind. As may be remembered, a young female threw herself from the top of the Monument, in London, a few years since; and so many followed her example, that it was found necessary to enclose the open space with iron rails to prevent the immolation of more victims. In Sparta, also, a suicidal mania seized the young maidens, which continued until the Senate, becoming alarmed, decreed that the corpse of each monomaniac should be dragged *naked* through the streets—the sense of shame overcoming the morbid propensity.*

Whether these conclusions be sound or unsound, valid or invalid, it is a curious psychological phenomenon, that the heresy, which Protestants say crept into the Christian church in the 7th century, was shortly after the rise of the last pestilential epoch; the same as the ritualistic heresy is contemporaneous with the commencement of the present epidemic period. It was, also, in the middle of ths 9th century, that the doctrine of the Real Presence, or Transubstantiation, was broached, having been first promulgated by Paschasius Rudburtus, a Monk of Corbie, in France. Not only was it considered a new doctrine, but it was strenuously opposed by some of the most

* For these reasons, the *Illustrated Police News* ought to be suppressed. Being filled, weekly, with representations of suicides, murders, and other acts of violence, they act directly as incentives to similar acts or crimes, by the impression produced on morbid minds. Hence it was, that Courvoisier attributed the murder of Lord William Russell to his having witnessed the representation of a similar scene on the stage!

learned men of the day. Rabanus Maurus, Archbishop of Mentz, condemned the new doctrine in these terms :—"Some, *of late,* not rightly conceiving concerning the sacrament of the body and blood of our Lord, have affirmed, that this is the very same body of our Lord that was born of the Virgin Mary, which *error* we have opposed to the utmost of our power." * The Emperor, Charles the Bold, having inquired of Bertramus, a Monk of Corbie, whether the doctrine were true, he answered :—"The difference between them (the bread and the body of our Lord) is as great as between the pledge and the thing for which the pledge is given; as great as between the image and the thing whose image it is; as great as between the representation and the reality." † Johannes Scotus, also, a celebrated Irishman and author, who wrote a treatise on the Eucharist, A.D. 880, by command of the same Emperor, thus expressed himself :—"The sacrament of the altar is not the true body, nor true blood, of our Lord, but only the *memorial* of the true body and of the true blood." (*De corpore et sanguine Domini*—a work that was subsequently condemned at the Synod of Vercelli, by order of the Pope). The celebrated Claude, Bishop of Turin, was equally opposed, in his writings, to the doctrine, and explained the Sacrament of the Lord's Supper in conformity with the definition given above. Although the heresy had reached England, it had not been adopted by the English Church a century after this, as the following extract will show :—Elfric, Archbishop of Canterbury, A.D. 996—a most learned man, and of such authority that his writings were accepted among the canons of the Church at that time—referring to the words of our Lord, thus wrote :—"Notwithstanding, that lively bread is not bodily

* Usser *de Christ. Eccles.*, c. 2, p. 16.
† Spanheim. *Hist. Christ.*, sec. 9, c. 18.

so, nor the self same body that Christ suffered in; nor is that holy wine the Saviour's blood, which was shed for us, in bodily thing, but in ghostly (spiritual) understanding."* So also in his sermon, he remarks:—"The Saviour saith, 'He that eateth my flesh and drinketh my blood hath eternal life,' and He bade them *not* to eat that body wherewith He was enclosed, nor to drink that blood which He shed for us; but He meant with those words that holy housel (bread) which *ghostly* (*i.e.*, spiritually) is His body and His blood, and he that tasteth it, *with believing heart*, hath eternal life." †

Notwithstanding these arguments and conclusions, and this opposition, the doctrine gradually spread, until the Mass became, at last, regularly established. It was not, however, until 1215, at the Council of Lateran, held under Pope Innocent III., that Transubstantiation was proclaimed a dogma of the Church, and decreed to be incontrovertible—all who opposed it being condemned to death, the civil power, at that time, being under the direct control of the ecclesiastical. It was for this purpose, that the Inquisition was established, by means of which, the fire, and the sword, 50 million Christians, at least, have perished, in order to force this doctrine on the consciences of its opponents; while Llorente, a Roman Catholic, and Secretary to the Inquisition in Madrid, in 1790, states, that but for the establishment of this Tribunal, "we should reckon 12 millions more inhabitants in Spain than at present." ‡ Strange to say, it is this very doctrine, repudiated by the Founders of the English Church, that has been re-introduced by the Ritual-

* Epistle to Wolfstane, Archbishop of York, in Fox's *Acts and Monuments*, vol. v., p. 277.

† Translated out of Latin into Saxon, A.D. 996, *Id.*, p. 287.

‡ *Histoire de l'Inquisition en Espagne*, vol. 4, p. 96. Paris. 1818.

ists; as, also, the "Sacrifice of the Mass," although this Rite has been pronounced to be "a blasphemous fable and dangerous deceit," in the 31st Article of Religion of the Church to which these men belong—Articles that they not only gave their assent to, at the time of their ordination, but swore to observe! Whether this be sane or insane conduct, I leave others to determine.

Independently of the human race, the brain of animals also becomes affected, at epidemic periods, giving rise to a variety of diseases. Examples of this have been already given in the previous chapter. One of the most common is hydrophobia. Not only dogs, but foxes, wolves, and other wild animals, are found to be simultaneously attacked. We have observed the same result during the present pestilential epoch, the disease having been gradually on the increase of late years, as shown by the number of deaths of persons that have been bitten; while it prevailed epidemically in 1871. Referring to this subject, the Registrar-General remarks: "Never before did so many die of this distressing disease. The deaths by it in the four years—1868-71—were 7, 8, 32, and 56."

As regards murrains, it is evident from what has gone before, that these have sprung up contemporaneously with diseases in the human race; have prevailed in the same intensity; have progressed along the same lines of the earth's surface, and have evidently been produced by the same cause. As the history of each of these Epizootics has been given in the 1st part of this work, it is unnecessary to enter into any further details on the present occasion. It is only necessary to add, that the ravages from these diseases—Eczema epizootica, pleuro-pneumonia and rinderpest, more particularly the former—have been great, and the pecuniary loss consequent on their prevalence enormous. According to the Hereford-shire Chamber of Agriculture, the actual money loss, from the foot-and-mouth disease alone in that county, in 1872, was as follows :—for cattle, 87,497*l.*; for sheep, 48,031*l.*; and for pigs, 4,019*l.*; total, 139,547*l.* As the number of cases, in this county, was reckoned at 9 per cent. of the entire stock; and as the returns give 9¾ as the average for the other counties, the actual loss for England this year would be, at the same rate, 11,736,215*l.* And, Mr. Gamgee, Veterinary Surgeon, calculates, that the losses in England from the prevalence of cattle diseases, during the last thirty years, has amounted to 300,000,000*l.*, or nearly half the national debt. This calculation has been confirmed by Mr. Kilby, from circulars sent out to, and returns given by, the Agricultural Societies and Chambers of Commerce. In addition to these diseases among animals, the feathered race has suffered at the same time; and, apparently, from the same cause, or the same disease, as man. This was more particularly the case in 1873. Referring to this subject, the *Daily News* remarked :—"The murrain amongst the grouse has set in with unusual violence this year. The reports from both the Scotch and Yorkshire moors state, that hundreds of the birds are picked up dead or dying in all directions. The disease appears to be as little understood as the Black Death of the Middle Ages, but, of course, theories without end have been broached to account for the epidemic . . . . Although we are as far off from a scientific explanation of the grouse disease as ever, there can be no doubt of the absolute reality of it at present; and should it continue at the rate of which we read, it will be absolutely necessary to close up a great many moors altogether for, perhaps, more than one season." (May, 1873). As regards the nature of the disease, it would appear to be a fever, having a great analogy with typhoid fever. Dr. Farquarson states, that "the result of investigation into the morbid anatomy of these birds tends to confirm, in my own mind, the theory suggested in a letter published in *The Lancet* last August, that the grouse disease consists essentially of a specific fever, propagated by epidemic or infectious influences, in the same way as cholera, typhoid, or enteric, among ourselves. The appearance of the liver much resembles that noted in the continued fevers affecting the human race, and the invariable presence of diarrhœa, as an early symptom, points in the same direction." *

Although not to the same extent, the vegetable creation has suffered in common with the animal, as previously shown. Up to the present time, the potato and the vine have been the chief sufferers from the operation of the morbid cause; the losses in the cereal crops being referrible to atmospherical causes rather than to actual disease. The result, however, of the ravages of disease among these two plants is sufficiently lamentable; particularly in those countries in which the potato is trusted to as the chief article of diet. This is the case in Ireland; hence the failure of the potato crop, in 1848, produced a severe famine; which, together with the ravages from disease, and emigration, consequent on distress, reduced the population of that island from 8,173,124 in 1841, to 6,532,385 in 1851; and this, too, notwithstanding the grants made by Parliament, to relieve the distress, amounting altogether to 10 millions sterling. Although there has been no actual famine, great distress has been experienced in Ireland on several occasions since, and particularly in 1872, and at the present time; and so it will continue as long as the potato is depended on, as the chief article of diet of the peasantry. Independently of actual

* *Lancet*, Sept. 5, 1874.

disease, the potato is liable, more so, perhaps, than any other plant, to be influenced by atmospherical vicissitudes. Hence the partial scarcity in Ireland, in 1814, -16, and -22. In a *brochure*, published in 1846,* I pointed out, that the potato disease is a true vegetable epidemic, and then added:—"If these inferences be just, we must conclude, that the cause productive of the disease, at present raging among the potatoes, will be again in operation in the next or subsequent years. It becomes, therefore, an important question to ascertain, what course should be adopted, under these circumstances, in order to guard against future failures in so principal an article of diet." (p. 6). As a consequence of this conclusion, I recommended that other articles of diet should be substituted for the potato; confining the cultivation of this root to light, sandy, and calcareous soils. But the warning passed unheeded, and we now witness the result. According to the returns sent in to the Local Government Board for Ireland, the potato crop of last year is stated to be deficient in quantity, poor in quality, and so injured by blight, as to represent not more than half an average crop. To add to the distress, there was a want of fuel, for although a great deal of turf had been cut, it could not be saved, on account of the continuous rains.†

* *The Cause of Blight and Pestilence in the Vegetable Creation.*

† As a panacea for all the ills under which Ireland is now, and has been for some time, suffering, a proposal has been made to give "fixity of tenure" to the Irish peasant. No greater curse could fall on Ireland than the granting of such a measure; it is the possession of land, which is the whole and sole cause of his present and past distress; for he has been leaning on a staff that has snapt asunder, and pierced him to the heart. And so it will be, as long as he possesses a plot of ground, and is enabled to cultivate his favourite root. The potato is, no doubt, a valuable

Similar results, and from the same cause, are being witnessed, at the present moment (Jan. 1880), in another country—in Silesia, East and West Prussia, and the Duchy of Posen; excepting that the horrors of

article of diet, when sound, as it contains all the elements necessary for the nourishment of the body, and in nearly the right proportions; but diseased potatoes are not only innutritious, but they may become actually poisonous. Although it is what Cobbett called the "lazy root of Ireland," requiring only a small amount of labour, and allowing the cultivator to pass a great part of his time in comparative idleness; it could, previously to 1846, be depended on to furnish the labourer with sufficient food, if his plot of ground were large enough for himself, his family, and his pig! Now, however, its proper designation would be, not the lazy root, but the "famine root" of Ireland. Why, we may ask, has there been such a difference between England and Ireland, and between the Irish in England and the Irish in Ireland, from the operation of precisely the same cause—the destruction of the potato crop having been as great and as complete in one country as in the other—yet there was no cry of distress in England, no application for State or public aid in 1848, or in 1872? The answer is sufficiently apparent. The English labourer depends for his sustenance on wages, not on the seasons or the potato crop; the failure of which falls on the farmer, who can better bear the loss, and who may be able to recoup himself for the failure of one crop by the profits derived from the cultivation of others. But the Irish peasant, if his crop fails, is thrown destitute on the world, without food and without money, and becomes periodically a State beggar. The only remedy for these evils would appear to be the abolition of small holdings, and the conversion of the land, in Ireland, into large farms, so as to oblige the peasant to work for money, instead of depending on the chances of a good or bad crop of potatoes; and there is no other single article that he could substitute for this esculent. He would then be placed, not only out of the reach of want, but might also be induced to direct his energies to other and more profitable industries, and particularly to that mine of wealth the fisheries; for, as Dr. Franklyn truly said, "he who pulls a fish out of the water, pulls up a piece of gold." Before 1848, Ireland imported from Scotland, every year, 120,300 barrels of herrings caught on her coasts, or in seas to which she has a greater facility of access than Scotland!

famine, and the want of fuel, are intensified by severe and unusual cold. "It has come like a doom upon the poor people, after a long spell of 'bad times,' and an almost total failure of the potato crop, upon which the peasantry of these comparatively sterile regions mainly depend for their winter sustenance. . . . We read of parents all but naked, in wretched, empty rooms, forlorn of fire, the corpses of their children, victims of typhus (hunger-typhus), lying uncovered on the floor. . . . We hear of women, driven to despair, lying down deliberately in the snow to die, in order to put an end to their intolerable misery." * Other, and still more terrible, famines have occurred in India, in China, in Persia, and in Asia Minor; but these are to be ascribed to vicissitudes of the seasons, or to drought, rather than to actual disease in the crops.

That great atmospherical aberrations have occurred during the period under consideration, and more particularly of late years, is a fact patent to all. It would be superfluous, therefore, to give a complete history of these phenomena; it will be sufficient to call attention to a few of the facts connected with their occurrence. These aberrations commenced with, or rather preceded, the rise of the epidemic cholera in India; a circumstance that was particularly noticed in that part of the world, for there the year being divided into the hot, the rainy, and the cold seasons—each characterized by a peculiar state of the atmosphere, which continues, with little or no interruption, for certain fixed periods—any alteration in the accustomed heat, or dryness, or moisture in the air, is better observed, and attracts greater attention, than in climates where the weather is more or less changeable during the whole year. These atmospherical vicissitudes commenced in India in 1816: a year marked by the

* *The Daily Telegraph*, Dec. 26, 1879.

absence of the accustomed rains, and the prevalence of great heat and consequent drought; so that the spring crop of grain was entirely destroyed. In the western parts of the province of Bengal, the drought was so uncommon as to dry up the rivers. In the upper provinces, says Mr. Jameson, the extraordinary scantiness of the rains was yet more remarkable. From Benares upwards, Oude, the districts within the Doab, and those west of the Jumna, were dried up by the long continued and unceasing heats. In September, this unwonted drought gave way, and was succeeded by heavy and incessant rains for many days, so that the whole face of the country was laid under water.* The ensuing cold season, also, both in the lower and upper provinces was raw, damp, and unpleasant, and throughout cloudy with frequent falls of rain. February had more the appearance of an autumnal than of a cold weather month. The next year—being that in which the epidemic commenced—was characterized by a very close sultry summer and autumn, and an excessively rainy season. "The weather should now, according to the common course of things," adds the writer of the report, "have become cool, settled, and fair: but the continuance of unwonted humidity and warmth in the air, and the frequent occurrence of rain throughout the month (November) proved, that the remainder of the year was to proceed with the same strange unseasonableness and insalubrity as that, which marked the early part of its course." The following year, viz. 1818, was remarkable for the like irregularities in the seasons. The hot weather set in about the 20th of February, being earlier than usual: instead of continuing, however, until the beginning of June, as is commonly the case, heavy rains were experienced about the end of

* *Bengal Report on the Epidemic Cholera.*

February. "This sudden change," says Mr. Jameson, "is worthy of particular notice; because *it was at this very time* that the epidemic, after dying away in November and December, and being nearly exhausted during January, took head; and, amongst the natives, raged with indiscriminate violence until the end of the following July. From this time, said one writer, while speaking of the remarkable vicissitudes, that had been experienced in the preceding years, the seasons, after so long a period of extraordinary deviation, seemed inclined to return to their ordinary course, and to abide by the laws marking their natural progress and succession. But this hope proved to be fallacious; for the like vicissitudes and the like changes have been experienced, more or less, from the above period to the present day; there being hardly an instance known of a visitation of the epidemic without its being accompanied, preceded, or followed, by changes in the weather or the seasons." In fact "the disease," to quote the words of another observer—and the remark has been made by most persons who have expressed any opinion on the subject—"has never appeared in India, during that portion of the year usually characterized by clear and serene weather, without producing some change."*

These aberrations recurred from time to time, and with greater severity, until, in 1838, a severe famine, as might have been anticipated, occurred. It was very disastrous in its results, but was exceeded in severity by another famine, in 1860. It had been preceded by great heat, and a severe drought, which produced a failure of the crops—this heat being coincident with unusual cold and wet in Europe. Speaking of this famine, the *Bombay Gazette* observed: "The famine of 1838 will, no doubt, be in the

* *Asiatic Journal*, 1818, p. 184.

memory of many of our readers; but it is to be feared, that the horrors of that famine will be surpassed tenfold, in the course of the next few months, in the north-west provinces. From Cawnpore to Saharunpore, and from the Ganges to the plains of Hissar, the country is a desert. The mortality, in one district of the central section, indicates that, notwithstanding all the large and liberal efforts of the Government and the community, not fewer than from 80,000 to 90,000 human beings must have perished of hunger, or diseases induced by hunger, within the limits of the central section alone. The loss in cattle amounted to 90,000, in the district of Bolundshuhur alone—a very large number for India. In 1866 occurred, what has been termed, the great Orissa famine, during which 1,200,000 human beings, it has been calculated, perished. There was another famine in 1868, a partial one in 1870, and severe ones in 1874 and 1877—all due to the same cause, a failure of the accustomed rains and excessive drought. Referring to the famine, or, rather, the scarcity of water, in 1868, Dr. Cunningham remarks: "In all the cases, the suddenness of death was the great peculiarity. There was no struggle for life (no stage of insensibility, accompanied by stertorous breathing). In most cases, the wretched victims, half delirious from the throbbing headache and burning skin, faint and labouring from a fearful thirst, staggered to the nearest stream or well, crying for 'water, water': but no sooner had they drunk copiously of, what they believed to be, the water of life, than their system suddenly collapsed: they fainted, and death released them from their sufferings." * The mortality from the last famine—that of 1877—was greater than either of the preceding ones. In Mysore alone, the loss was estimated, by some writers, at one

* Report of the Sanitary Commissioner for India.

million, and by Mr. Digby at 1,250,000; or, one-fourth of the population. The same estimate is given, by the last-named writer, of the mortality in Madras, in the worst parts, and about three millions out of seventy in all the affected districts.* The total loss, therefore, from starvation and disease, during this severe visitation, may be set down at from four to five millions at the lowest estimate. Simultaneously with the prevalence of this famine in India, China was afflicted with a similar calamity, and from the same cause: no rain having fallen in the four northern provinces, chiefly affected, for *three years* previously. The accounts from this country are still more harrowing than those from India, as will be evident by the following extract from a memorial of Li-Ho-Nien, governor of Houan and Yuan, appealing for State assistance. "In the earlier period of distress, the living fed upon the bodies of the dead; next, the strong devoured the weak; and now, the general destitution has arrived at such a climax, that men devour those of their own flesh and blood." This is confirmed by the Roman Catholic Bishop of Shansi, who says: "The husband devours his wife: the parents eat their sons and their daughters, and, in their turn, the children their parents." The province that suffered most is that of Shansi, or the Western Hills, in the north of China. It is one of great natural beauty and fertility. Wheat, rice, millet, and Indian corn, are usually grown there in great abundance. The correspondent of the *Times* at Shanghai, writing on April 27, 1878, says; "Unless relief comes at once, the population of Tai Yuen, the provincial capital of Shansi, in which the distress is the greatest, bids fair to become absolutely extinct. The population has diminished from 1,000,000

* *The Famine Campaign in Southern India.* By W. Digby. London. 1878.

to 100,000; and the Chinese papers have given the number, who have died of starvation, or met the awful fate before recorded, at over 5,000,000." And the famine had not then disappeared. These aberrations cannot be referred to climate only, or tropical heat; the opposite state, or extreme cold, having also been experienced in India, as was the case in 1871-72. "At the camp at Delhi," remarks one writer, "the cold is described as *intense*. Simla is covered with snow, and Christmas has been celebrated there, this year, with blazing fires, English fashion." * The cold was equally severe in the south of China, and to such an extent that ice appeared both at Canton and Hong-Kong—a phenomenon never before observed by the oldest inhabitant. At Shanghai, skating was indulged in by the Europeans.

There are few accounts of the destruction of the crops, in Asia, from the opposite series of phenomena, or from excessive rain and inundations. In 1868, however, India was deluged with rain. In Bengal, 78 inches of rain fell in nine months, being 11 inches above the average, and 25 above the corresponding period of 1867. A correspondent of one of the daily papers remarks: "Orissa was swept; the other districts between Calcutta and the sea are still four feet under water; even more distant Tirhoot was deluged. The rice crops rotted; those sown a second time are now rotting before my eyes. . . . A week ago, when we should have been parboiled by heat and damp, the first breath of the cold season came, and the apprehension is spreading that even Eastern Bengal will suffer again. . . Nor has Western India escaped the deluge. At this time last month it inundated Guzerat. Ahmedabad, Kaira, Surat, and the other great old cities there have been desolated. Houses have fallen down by

* *Homeward Mail*, January 1872.

tens of thousands, and lives, both European and native, have been lost, while railway bridges have been washed away." The same result was observed in China, on the termination of the drought there. A Chinese newspaper, the *Sinpao*, says: "In this our Middle Kingdom, successive years of drought and dearth have turned the provinces of Shangtun, Shansi, Houan, Shensi, and Chihli, into a vast expanse of desert wastes. In Kwantung, and Chihli too, have disasters by floods occurred; when embankments were burst through and dykes broken down, the waters drowning and swallowing up the full-grown grain." That they will recur hereafter, and to a much greater extent, there can be no doubt; great drought having invariably been followed, at a longer or shorter interval, by heavy falls of rain, floods, and inundations.

Although the accounts from these countries are necessarily imperfect and meagre, it is yet evident, that the same atmospherical phenomena were observed along the route taken by the epidemic cholera from India to Europe. Thus, the Apothecary-in-chief of the hospital in Cairo stated, in a letter addressed to the editor of a French journal, that the sky, on the approach of the cholera to that city, and for some days before, produced a feeling of horror, from the peculiar appearance of the sun—the rays of light being obscured, although there was not a cloud. Dr. Hedenhof, the Swedish savant, in a letter published in the *St. Petersburg Journal*, also informs us, that all the East—Asia Minor, Egypt, the Archipelago, Turkey, &c.—had been, in 1823, a prey to an influenza. This epidemic, continued the writer, although of a different nature from cholera, which preceded it, appears to be subject to the same *atmospherical influences*. The winter had been more severe than was ever known before. At Tiflis and Georgia, where cold weather is scarcely known, the thermometer fell many degrees below the freezing point. No other accounts appear to have been recorded of similar phenomena until 1871, when the attention of Europe was directed to Persia, in consequence of a severe famine that then prevailed. It had been preceded, for three years, by a drought, which had not only destroyed the crops, but had dried up nearly all the springs. To give an idea of the extent of the calamity, it may be mentioned, that at Meschiæ, the capital of Khorassan—a town of 120,000 inhabitants—80,000 are said to have died of starvation up to Aug. 7th ; more than 20,000 had fled the city ; while, of those who remained, the majority had been seized by the Afghan tribes, and carried into slavery. The famine was felt, not only in the cities, but with equal, if not greater, severity among the two millions of pastoral nomads—the Bedouin tribes. As the horses and camels had died from the want of food and water, they were unable to seek fresh pasture beyond the famine-stricken country. Many, who attempted to reach the frontiers, died on the road, leaving their bones to whiten on the sands of the desert or on the arid plains. At Ispahan and Shiraz, the inhabitants had been driven by hunger to eat their own children ; and the Governor of Shiraz had been compelled to place a guard at the cemeteries, to prevent the peasants disinterring the bodies, and converting them into food. To the horrors of famine were added those of disease ; the population being decimated, at the same time, by both cholera and typhus. As the drought had prevented the annual crops from being sown, the famine continued, not only during the whole of 1871, but to the end of 1872. To add to the sufferings of the people, the cold in Persia, during the previous winter, had been unusually great, and snow fell in large quantities. The Rev. Robert Bruce, in a communication to the Church Missionary Society, dated

January, 1872, says: "Snow continued since my last, in the severest manner, for 40 days. . . . Mortality at Ispahan excessive. To devastating famine is superadded the natural sequel—disease, combining the worst symptoms of the plague." The typhus of the previous year had, therefore, culminated in plague; thus affording another instance of the truth of the conclusion before drawn, and so frequently insisted on, that these two diseases are merely different forms of the same complaint, varying only in intensity.

Precisely the same results have been observed in Europe, the epidemic cholera having been preceded, accompanied, and followed, by great atmospherical aberrations. Dr. Forster, while alluding to these phenomena, remarked: "I consider, what I call, the epidemic period as having begun as early as September 1828, when that extraordinary *lumen zodiacale* was seen to stretch across the heavens. I have, also, traced a succession of atmospheric changes since that period, so that the spring of 1829 became remarkably unhealthy; while the mortality, in some countries, was prodigious, and the cold of the summer in some parts of Europe as extraordinary. I was at Spa, in the end of May 1829, and I remember, *while examining the substance thrown out by an earthquake* there, to have found the cold as great as in winter; and, on the morning of the 8th of June, there was ice on the puddles of water by the banks of the Meuse, near to the town of Namur; I learned, also, from couriers, that the cold was severe all along the Rhine, and even in Austria. At Louvain, they told me everybody was more or less ill; and I heard the same at Aix-la-Chappelle: a warmer air began at Cambrai, and it was as warm as usual at Paris; but in Spain, I find the cold was great. The winter of 1829-30 which followed, was one of unusual severity all over the world;

even in the south of Spain and in Africa snow lay on the ground, and in most parts of Europe covered it, from November 1829 to the end of February 1830. The cholera morbus then broke away from India, and began its deadly course towards Europe, but did not arrive in Russia until the following spring. During the present year (1831) the cholera morbus has been making a certain progress, while milder sorts of epidemics have either been its precursors, have followed in its train, or have appeared in its outskirts. In England and France, for example, we have had the *grippe;* the epidemic cough in July, and the affection of the bowels in August and September."* The greater number of physicians, says one author, speaking of the slighter affections, which ushered in the epidemic cholera in Berlin, attributed these accidents to the influence of the summer; which was hot and wet, with a remarkable absence of all storms. A singular and almost unknown circumstance, continues the same writer, also contributed to augment the humidity of the atmosphere: this was the inundations of the banks of the Spree—a phenomenon which was several times repeated without its being possible to explain properly the cause. These spontaneous inundations were observed at the same time in Russia, in Poland, and in a great part of Prussia.†

The same aberrations were observed both in England and in America, while they have been gradually increasing in frequency and intensity, up to the present time. Of these aberrations, the most remarkable, perhaps, is the tropical heat that has been experienced on some occasions, and more particularly in 1868. In Paris, the mean temperature for the month of May, this year, amounted to 70 degs. Fah.—the average for the previous 50 years

* *Essay on the Cholera Morbus.*

† *Relation de l'Epidémique du Cholera qui a regné à Berlin.*

being only 57 degs.—13 degs. less. The only exception to this was in 1862, when the mean reached 62 degs. The temperature was equally high in England; and in June, it was still higher. Referring to this month, Dr. Fielding of Tunbridge, states: "The heat culminated on the 27th, when the shade standard self-registering thermometer, by Negretti, indicated the extraordinary, and, as far as I know, unparalleled height in this country of 96.7 degs. It had previously registered 95.5, 94.6, and 94 degs. on the 17th, 13th, and 26th; and 91.5, 90.3, 90, and 90 degs. on the 20th, 16th, 15th, and 14th respectively.* But for the heavy dews which followed at night (as in the Tropics), reducing the temperature considerably below the average, and thus refreshing the drooping plants, much vegetation must have perished. As it is, everything looks as brown as at the end of autumn." In Paris, the thermometer reached 100 degs. Fah. in the shade, for several days. In July, the temperature, in England, was still higher than in the previous month. The same observer, Dr. Fielding, in a letter to the Editor of the *Standard*, remarks:—"Since I last wrote you the account of June, the temperature has been higher than ever, and, I believe, greater than any on record in this country. Before having recourse to figures (as I find my brother meteorologists are a *genus irritabile*, greatly endowed with the *disputandi pruritus*), I think it as well to prevent cavilling by stating, that I hope I may be trusted, as I was, for a long time, one of Mr. Glaisher's staff of observers, and my registers were published by him, and also in the Registrar-General's reports; they have also been read in the Royal Society, and Mr. Symons publishes my rainfall regularly. My instruments,

* Dr. Fielding states, that these temperatures are the highest he has registered, during an experience of 40 years.

as I have already stated, are standard ones, which have been compared with the standard of the Royal Observatory, and their index errors given. They are in a well-protected stand in my garden, entirely detached from all buildings, and free from accidental radiation. They face to the north-east, are four feet from the ground, and 75 above mean sea level by the last Ordnance survey. Having premised this, I shall at once state, that Wednesday, the 22nd inst., was the hottest day I ever knew in my life; and I may add, I never wish to experience such an one again. A self-registering sun thermometer, by Negretti (index error, 0), indicated, when placed on the lawn, 142 deg. A standard self-registering thermometer, in perfect shade, also by Negretti (index error, 0.1), gave the extraordinary result of 100.5 deg. A standard self-registering minimum thermometer (index error, 0) fell to 60.5 deg in the night. This gives a range of temperature, in shade, of 40 deg., a mean temperature of 80.5 deg., and an entire range, with sun maximum and shade minimum, of 81.5 deg. in the day." Dr. Fielding then adds, "that for the whole month of July, the day maxima are 15.542 degrees above our average; the minima, 3.973 degrees, and the mean temperature, corrected, 9.396 degrees in excess of our average. July was an almost rainless and June a completely rainless month; thus causing a severe drought as well as heat." As a consequence of this unusual heat, many deaths occurred from sunstroke—a result rarely witnessed in England, at least in this century.

This abnormal heat was not confined to Europe; the same result, and to a still greater degree, was experienced in America. There, the range of temperature, according to a communication from Washington, dated July 17th, was as follows:—"Washington, 98 deg. to 106 deg.; New

York, 95 deg. to 104 deg.; Philadelphia, 94 deg. to 98 deg.; Ponglekelpsie, New York, 105 to 114 deg.; Albany, New York, 100 deg. to 104 deg.; Cape May, New Jersey, 68 deg. to 75 deg.; Toronto, 97 deg. to 100 deg.; Montreal, 98 deg. to 105 deg.; Cincinnati, 98 deg. to 100 deg.; Chicago, 94 deg. to 97 deg." As one writer facetiously observed, "Whether or not some unheralded and unexpected comet has given these States a slap with its tail, the state of the atmosphere might justify such a belief. In the shaded room in which I am writing, the index of the thermometer stands at 98 deg." And another added :—"However, this American sun has, since Friday last, been as fatal to our people as a pestilence. In 37 cities and towns in the United States there have been, since Friday, more than 1,700 fatal cases of sunstroke, and more than 7,000 cases not immediately fatal. In the city of New York alone, during Monday, Tuesday, Wednesday, and Thursday, 450 deaths from sunstroke were reported by the registrar of vital statistics. Of these, nearly 200 were reported by the police alone at the several stations. The lists of victims, as printed in the New York papers, look like the lists of killed and wounded of a great battle; their headings are almost the same—'The Dead,' 'The Suffering,' &c. During any one of the four days named, it has been almost impossible to walk a square in New York without passing a knot of persons, collected about a dead or dying victim of the weather; and every apothecary's shop has had its curious mob peering in at the lifeless form on the counter. It has been easy to trace out the lines of the street railways in New York by the dead horses alone. In the Central Park, in the great manufacturing establishments, on the highways, and in the docks, work has been totally suspended in New York. The papers print directions for the prevention of sunstroke, and for the treatment of sufferers. Among the victims of the prevailing epidemic is Dr. W. G. T. Morton, generally known as the first person to employ sulphuric ether as an anæsthetic in surgical operations. Dr. Morton was struck down near the Central Park in New York, after he had descended from his carriage at a wayside tavern. He died in a few minutes."

Like 1868, the year 1870 is also memorable for the absence of rain, and the consequent drought. In England, the dry weather usually commences the latter end of July; the rainy season being April, May, and the first half of June. But this year, the amount of rain that fell at Stroud, in the months of April, May, and June, as shown by Mr. Taunton, was only 2.80 inch, being exactly 4 inches less than the average of the 25 previous years. At Greenwich, the quantity was even less; out of 86 days, 70 were rainless. The result of the drought is thus described in the *Pall Mall Gazette*:—" In whole districts the hay harvest is a solemn farce. Roughly speaking, a hundred acres of meadow land may represent a loss of six times as many hundred pounds to its unlucky owner. Peas, parched to bullets in the pod, go for a third of last year's prices; in many places, the profits will not cover the seed; and unless the weather break, this first loss is but the beginning of the end. Pastures and downs are burning bare and brown already. If you turn to the turnip fields the prospect is blacker still, for these do not show the smallest symptoms of verdure." This drought, which commenced the 17th March and continued to July 31st, thus lasted 137 days. A second drought of 23 days was also experienced; it began on the 14th September, and ended on the 6th October. Only a small quantity of rain fell in the interval, the total registered for the first nine months of this year being only 13.50 inch.—exactly 6.85 inch. below the average of the previous 11 years, which also include three years of drought. The heat was equally great in France, and still greater in America. Some idea of its intensity may be gleaned from the following account by a correspondent at New York :—" The intense heat, of which complaints have been made at intervals all through the summer, seemed to reach its maximum during the last weeks of July, and the sunshine grew as fatal as an epidemic. Ninety-one deaths, in a week, from sunstroke are sufficient to account for the opening of a sunstroke hospital in New York, where two house-surgeons are kept actively at work. Another very sensible idea, which proves, however, the frequency and danger of the attacks, is that now adopted of having horse ambulances in the public streets, which at once convey the stricken to their homes or to the hospital. Since these means have been adopted, fully two-thirds of those attacked by sunstroke recover; but the mortality of the city, during the week ending July 24th, was 341 in excess of the estimate, the increase being attributed by the registrar to the excessive heat. When the hot weather began, the deaths it occasioned were those of old men and young children; but, lately, the young and middle-aged have been affected. Curiously enough, one of the victims has been a negro woman, the surgeon who attended her observing, that he had never known one of her race succumb to the effects of heat before.* The intense heat extends, it is said, over a given space both in the Old and New Worlds, while, strangely enough, in

* There were 60 deaths on one day from sunstroke, in New York, in the month of July. On the same day, the French Minister shot himself, in a fit of temporary insanity—the effect, it is supposed, of the heat and over-fatigue.

mid-ocean the 'Cambria' and 'Dauntless' have encountered rains and foggy weather." The death of a negress, and a similar result was observed previously with natives of India, from sunstroke, or, heat apoplexy, as many persons are attacked and carried off without being exposed to the rays of the sun, is a very remarkable phenomenon. A negro, both in the West Indies and in Africa, will continue at his work all day in the fields, with a nearly vertical sun on his head, with impunity. The same may be said of the natives of India. Look, for instance, at the palanquin-bearers, who will travel all day, with their half-naked bodies and *shaven heads*, exposed to the rays of a tropical sun without any ill result. We may therefore conclude, that there is, in these instances, some other agent than heat concerned, and mainly concerned, in the production of the effects then witnessed. Even Switzerland has not escaped these abnormal accessions of heat. The Editor of the *Swiss Times*, writing in Jan. 1871, remarks; "For the last two or three years, it has been the general opinion, that the weather has gone mad—seized with a kind of hydrophobia—for we have had no rain here for the last three months, and water, in some places, is so scarce, that high prices are paid for it." In England, also, the heat was excessive the following year—the mean temperature for the week, ending July 27th, being 71.1 degs. or 9.3 degs. above the average for the previous 50 years. In America, the heat was still greater, as will be apparent from the following extract of a letter, dated New York, July 6th, 1872:—" The terrible heat of the last ten days is the topic that forces itself upon the attention of all. Never, perhaps, in the recorded temperature of this country has the mercury for so long a time shown so high a range in New York. That it should get into the nineties in

July is so much a matter of course, that it is no more deserving of special notice, or comment, than that the days are longest at the summer solstice. But that day and night, for nearly a fortnight, the heat of our dining-rooms and bed-rooms should exceed the artificial warmth that we give to our graperies and conservatories, or what is felt when one enters the Royal Palm House at Kew Gardens; that men should drop down daily in the streets, beneath the destruction that wasteth at noon-day; that it should become almost as dangerous to walk from one's place of business to one's home as to ride across a line of fire in battle, is something that may well startle the least impressible citizen with a sense of insecurity. And yet, such are the conditions under which we live in New York at this moment. From three hundred to four hundred persons are every day struck down by *coup de soleil;* and of these cases there has been, since the beginning of the excessive heat, an average of seventy deaths. The victims are not confined to the lowest and humblest classes of society. Men addicted to strong drink, and labourers, the nature of whose work exposes them to the direct rays of the sun, such as road builders, masons, and carpenters, naturally succumb the soonest to the oppression. But men of wealth and leisure, and of the most abstemious habits, have given way in a moment, and with no premonitory exhaustion, to the death stroke. It recalls the wrath of Apollo upon the children of Niobe. Meanwhile something like paralysis has seized upon the city. . . . . To give the height of the mercury is but a poor way of indicating the oppressiveness of a hot season; but when you hear, that the range has been from 82 deg. at early morning to 102 deg. at three p.m., and that, for the greater part of the time, it has actually been above 94, you will at least be able to form some idea of our sufferings."

At other times, instead of heat and drought, the opposite series of phenomena, or excessive rains, floods, and inundations, have been observed. This was the case in 1860, which was the wettest year in England of any previously recorded in the present century. A correspondent of one of the papers, speaking of the unusual weather of 1860, remarks: "It has rained as if the deluge were again come upon us; and for 40 days and nights the windows of heaven were opened. The temperature in June has been colder than Christmas. In 1859, the wheat in the field before our door was in ear on the 5th May; in 1860, there is no appearance of it on the 23rd June." In 1862, floods and inundations were almost general on the Continent. In Vienna, a population of 80,000 had to be lodged and provided for—the district in which they lived having been entirely submerged. A still more serious calamity befell the fair and fertile province of Valencia, in 1864. An English resident, writing from Dænia, in Nov., remarks:—"A summer of considerable heat and drought—not a single shower having fallen between 30th April and 25th August—has been succeeded by an autumn of unusual severity. On the night of the 3rd instant, there was a copious fall of rain, which continued on the morning of the 4th; and, towards the evening, it seemed as if the windows of heaven had opened, and another deluge were inevitable—the rain descending in torrents, of which persons who have seen only English drizzling can form no adequate conception. As night approached, the water in the streams, rivulets, and rivers, rose with incredible rapidity, and the rains fell faster and faster. Still there was no dread of an inundation of a serious character. Experience had never taught the inhabitants or their fathers to expect one. True, the Jucar and its tributaries had overflowed on former occasions, and, in 1805, rose to an unusual height, but the damage done was only trifling, and few of the present generation recollect it. Not so, however, on this occasion. Before midnight—a night of fearful darkness—the towns of Cullera, Alcira, Carcagente, and Jativa, with many adjoining villages, were submerged in water. In Alcira alone, which is the largest of the towns just mentioned, upwards of 200 houses near the banks of the river were completely swept away; others have fallen since, and many have had their foundations sapped. The poorer classes, whose houses were of one story only, were obliged to get on the roofs to save themselves from being drowned. Thousands from their housetops anxiously looked for the morning. There was no escape. The water had risen to a height of six or eight feet in the highest parts of the town—in the lower parts whole houses were covered. In the convent of Carcagente the water was 15 feet deep. Except cats and dogs, not a single domestic or farm animal has been left alive. . . . . The second night was much more terrible than the first. Days had passed—day, the time of hope—and no succour had arrived or could arrive. The rain again fell in torrents, the lightnings flashed with terrific vividness, the rolling thunder, peal after peal, succeeded—

> 'And then all was hushed,
> Save the wild wind and the remorseless dash
> Of billows; but at intervals there gushed,
> Accompanied with a convulsive splash,
> A solitary shriek, the bubbling cry
> Of some strong swimmer in his agony.'

"It is not, however, till we come to the town of Carcagente and the neighbourhood, that the full proportions of the inundation begin to appear. Here, for miles around nothing was visible but an immense lake. In the village of Tous, consisting in all of about 200 houses, the court-house, the abbey, with all the parish records, the cemetery, and 107 private houses, have been completely swept away. In all directions, 'horror wide extends his desolate domain,' and of those who have

> 'Sunk into the depths with bubbling groan,
> Without a grave, unknelled, uncoffined, and unknown,'

there is no means of forming anything approaching an accurate estimate." Although not followed by the same disastrous results, unusually heavy falls of rain, with their attendant floods and inundations, have also been experienced in England. This was the case in 1866. In the months of June, July, August, and September, 20 inches of rain were registered; being 8 inches above the average of this century. The total rainfall for the year was 30.89 inches, or, 7 inches above the average. In November, extensive inundations occurred, particularly in Yorkshire and Lancashire. One writer describing these calamities, observes:—"This year indeed would seem one, in every sense, of exceptional phenomena. We have witnessed murrain, pestilence, hurricanes, terrible fires, and great floods. For several weeks past the rainfall, especially on the Yorkshire, Lancashire, and Derbyshire hills, has been extraordinary; but up to Thursday night last no particular danger was apprehended. In the dark hours, however, the people were roused in all directions by that peculiar sound, sullen and hoarse, which indicates the gathering of the waters, and, before dawn, there was a vast spread of ruin over two of the broadest English counties. The Irwell, the Irk, and the Medlock, had burst their boundaries, and run through Manchester as wide and roaring torrents, carrying along their course the huge bulks of uprooted trees, cottage staircases, barrels of oil and paraffin, mill machinery, the roofs of houses, and an indescribable *mêlée* of wreck. The inundation swept over villages, rolled into cellars, and invaded warehouses and human habitations up to the second storey; drowned horses and cattle; swamped the Peel Park; extinguished the furnaces in the factories; stopped trains at full speed; washed the ballast from the lines; submerged immense sweeps of field and pasture so deeply, that the hedges disappeared from sight; choked tunnels, and swept away many human beings to their deaths on the banks of the Aire. There were boats navigating the streets of Wakefield, and waggons engaged to rescue the people imprisoned in their dwellings by this fatal deluge; hundreds of mills are stopped, and thousands of hands, as an inevitable consequence, will be thrown out of employment. In Avenham park only the tops of the trees can be seen. Ships ride upon the very quays; bridges have been shattered to their foundations; chimney-stalks have been literally flung bodily from their foundations, and the Valley of the Calder for five miles is an unbroken lake. . . . . The remarkable characteristic of this visitation is the extensive area of the tract over which its ravages have been carried. It has assailed Manchester, Lower Broughton, and Strangeways; it has swept through Blackburn, Darwen, and Stockport; it has broken over entire quarters of Preston. It has laid waste whole districts in and about Wakefield. It has closed the roads to Huddersfield from north and south. At Leeds, all the low-lying parts of the town are several feet under water; and at Manchester alone it is computed, that nearly a thousand persons have been made temporarily homeless." To these disasters must be added the loss of life, some 30 or 40 persons having perished, the greater number by the breaking of a bridge at Leeds. In France, floods and inundations had also been experienced some months previously to this. The year 1867 was also an unusually wet one; and remarkable for the quantity of rain that fell in London on one particular day, the 26th July, viz., 3.30 inches—being the greatest previously recorded in this part of the world. Nearly the whole of this rain fell within the space of nine hours; so that about $\frac{1}{8}$ of the average annual rainfall descended in this short space of time. As, also, it was not confined to one portion of the metropolis, but extended over the whole metropolitan area, this district was deluged with 26,000,000 tons of water, according to Mr. Bazalgette's calculation, in the short space of nine hours.* This would be at the rate of about 220 tons per acre. It appears that this extraordinary rain-storm prevailed very extensively. The lower part of Chatham was so deeply submerged, that the steam fire-engines of Her Majesty's dockyard were called out to contend with flood instead of fire. In Essex, the country for miles was like a lake. At the Malton Station, on the Great Eastern line, four-and-a-half inches of rain fell between the 15th and 24th instant, which exceeded all previous records in the month of July, the average for this month being only 2.20 inches. As far north as Edinburgh, the clouds poured down their deluge, the fall in the Scottish metropolis being five inches in four days.

Although we have no meteorological records to refer to, the fall of rain must have been still greater on the Continent, judging from the floods that occurred. A correspondent to one of the daily papers remarks: "The most appalling scenes are reported from Beraun. In consequence of the torrents of rain, the two little insignificant

* Report presented to the Metropolitan Board of Works, August 9, 1867.

streams the Mze and Litovka, which join there, swelled to such a fierce height that at first they carried away all the moveables on the borders; but the fury of the elements did not stop there; for soon all the houses were washed away by the torrent, on which roofs of houses, furniture (even pianos), carts, hurdles, agricultural implements, goats, pigs, poultry, rafters laden with people, dogs, and cattle, were seen drifting. The latter were soon capsized or dashed to pieces against some tree, and all disappeared in the whirlpool. It was a terrible scene to view their last struggle for life, and to see them perish by miserable deaths; whilst there was not the slightest possibility of their being helped by their friends, who looked on from the few high and dry points in the neighbourhood. About Zditz the Litovka has destroyed everything, standing crops and houses. The village of Kredla, with 75 houses, is a heap of ruins, and 25 inhabitants were drowned. Similar scenes of woe took place at some localities of the north-eastern portion of the kingdom—Kronov, Nachod, Dobrichovitz, Adersbach, Braunau, &c. The material damage inflicted on these districts is roughly estimated at 2,000,000*l*. The watering-place Karlsbad has been severely visited. A telegram mentions sixty-four dead, and the destruction of more than one hundred houses. Thousands of the survivors are without shelter, and suffering the torments of famine. The village of Praskoles, near Karlstein, which stood close to the Moldau, has been carried away very suddenly, and most of the inhabitants are missing. The Jewish town of Lieben has been flooded up to the first-floors. The town of Konigsarl, in the delta between the two arms of the Beraun and the Moldau, has had the same fate. Other parts of Germany were also visited by terrible storms, accompanied by heavy falls of rain, and resulting in a wild bursting of bounds by various rivers.

Near Glatz, in Prussian Silesia, the same storm, which worked so much mischief in Bohemia, caused terrible havoc and the loss of several lives. Darmstadt seems to the traveller a place which, so far from being in danger of inundation, would benefit a great deal by a little more water. Yet a suburb of Darmstadt was for two days under water, and along the whole of the Berg Strasse the little hill or mountain streams, swollen to resistless torrents, have committed the most serious devastations." The same unprecedented floods occurred in France and in Italy. In 1868, the incessant rains of the spring and summer caused the seed to rot in the ground, and produced a famine accompanied by typhus, in eastern Prussia. An area of 500 square miles was thus blasted, and a population of 1,300,000 souls afflicted with the most dreadful of human agonies—hopeless hunger. The overwhelming cold increased these miseries, while fuel was a luxury; for the peat, on which the peasants depend, had been so drenched, that it was not then dry. According to the correspondent of one journal, "Across the Polish and Russian frontiers, adjoining that of East Prussia, a similar and even more desolating popular affliction—the "typhus of hunger," a French journalist calls it—has broken out, wasting away the people, leaving the traces as of a protracted and relentless war, filling the streets and highways with starving mobs, provoking outrage and pillage in bakers' shops, exasperating poor wretches to crime, and degrading large districts into universal pauperism. Nor does the havoc of the Russian famine end there. Over wide territories, the harvests have been blighted in the bosom of the earth; the cattle are perishing by myriads, through the deficiency of fodder and the severity of the weather; the numerous population usually engaged in wood-cutting in the forests finds its occupation gone; and the suffering spreads from the town and hamlets far over the steppes on the eastern side of the empire, until it reaches and ravages even the migratory tribes whose flocks and herds, towards Siberia in one direction, and towards China in another, have been more or less smitten."* And the writer then adds: "We have, as yet, no historical or scientific warrant for explaining, upon any theory, the origin of these tremendous popular disasters; although the assertion, long maintained, that they are periodical, and return, almost regularly within given cycles, appears likely to establish its credit with the world. Happily, the Indian plague of hunger has passed away, and there is reason for hoping that, in our most brilliant Eastern dependencies, precautionary measures are possible which may avert such calamities for the future. Nearer West, however, the problem seems more difficult to solve, and, in some instances, would daunt the boldest speculation. It may be taken generally, no doubt, that the intense bitterness of the season, felt all over the Continent, is aggravating the common distress; yet this does not account for the ungrateful harvests of a sultry autumn; it does not explain why the same curse has fallen, simultaneously, upon the peasants who dwell on the parched hills about Jerusalem, and the shepherds who are dying of want on the frozen pastures of Algeria, on the squalid rustics of the Russian borders, and the citizens of Konigsberg, Tilsit, and Memel."

In some instances, instead of an excess of the sun's rays, there has been a deficiency, with sunless seasons, of which the last year, 1879, affords a memorable example. Down to the end of June, there had been no summer, no spring. April, May, and June were sunless, and rain was nearly constant. July was no better, being, according to Mr. Glaisher, one of the most remarkable on record. "It

* *The Standard*, January 13, 1868.

was dull, cold, and sunless, with many days of temperature from 7° to 9° below their averages. Rain fell on every day during the first half of the month, and frequently afterwards: while *snow* fell at Bolton on both the 4th and 8th; and at Cockermouth on the 9th." September brought little improvement. "For a few days no rain fell, but from the 6th, it rained almost every day; and the rest of the month it was cold and gloomy." No record having been kept, until lately, of the number of hours of sunshine, each day; it is impossible to draw any comparison between this year and former ones, in this respect. As, however, sunless seasons are always colder than others, a fair idea may be formed of the exceptional character of this year, by a comparison of its temperature with previous ones. This has been done by Mr. Glaisher, and he has found that, with two exceptions, the year 1879 exhibits the lowest temperature of any other, during the present century; having been for the eleven months—November to September—46° 14. The mean of the same months, during the same period, being 48° 3. This year was also the wettest of any recorded in the present century. During the last quarter of this year, rain fell on 53 out of 78 days; and the amount collected was 11.75 inches, of which 5.2 fell in August. The previous instances of such a large fall, in this quarter, are, (1) in the year 1828, 13.8 inches; (2) in the year 1829, 12.3 inches; (3) in the years 1839 and 1867, 11.4 inches; and (4), in 1875, 10.3 inches; in all the other years, the fall has been less than 10 inches. When the above amount is added to the fall of the previous six months, it gives the unprecedented total of 29 inches to September 1879. The nearest approach to so heavy a fall of rain was in 1828, when 26.5 inches were measured, in 1866, when there were 24.8 inches, and in 1867, 24.0 inches.

The lowest amount recorded, since 1815, is 10.9 inches, in 1870. These facts are exhibited in the following Table, copied from Mr. Glaisher's: the insertion of which may also be useful for future reference.

TABLE showing the fall of rain in the nine months ending Sept. 30, from 1815 to 1879.

Year	Amount in Inches	Year	Amount in Inches	Year	Amount in Inches	Year	Amount in Inches	Year	Amount in Inches
1815	16·1	1828	26·5	1841	21·2	1854	13·3	1867	24·0
1816	21·2	1829	21·8	1842	16·3	1855	13·7	1868	16·1
1817	20·6	1830	21·8	1843	17·6	1856	18·3	1869	17·0
1818	19·5	1831	21·1	1844	16·2	1857	15·4	1870	10·9
1819	22·0	1832	14·0	1845	16·6	1858	14·2	1871	19·1
1820	21·0	1833	14·6	1846	17·6	1859	17·2	1872	18·7
1821	22·0	1834	16·8	1847	11·8	1860	25·1	1873	17·9
1822	17·1	1835	18·1	1848	22·9	1861	13·7	1874	12·8
1823	18·1	1836	18·7	1849	17·1	1862	19·7	1875	20·1
1824	25·4	1837	15·4	1850	14·5	1863	15·2	1876	13·7
1825	15·2	1838	16·8	1851	19·7	1864	12·4	1877	20·0
1826	16·9	1839	20·9	1852	22·2	1865	19·3	1878	22·8
1827	15·6	1840	13·3	1853	22·5	1866	24·8	1879	29·0

As a consequence of these aberrations, which have also been experienced, to a greater or less extent, in other countries, and particularly on the Continent, the wheat crop has been diminished, according to the best authorities, in the following proportions.

In Spain, one-seventh less than the average.
In Russia, one-fifth ,, ,, ,,
In Austria, one-fifth ,, ,, ,,
In Italy, one-fifth ,, ,, ,,
In France, one-quarter ,, ,, ,,
In England, nearly one-half

or 47 million bushels instead of 83 millions. Turkey, Roumelia, and Algeria also show a diminution.

But the catalogue of atmospherical aberrations is not yet finished. There are the storms, which have been gradually increasing in frequency and intensity during the same period. This is a fact, that must have forced itself on the attention of most persons ; it may not, however, have been so generally remarked, that the storms of the present epoch have been gradually assuming the characteristics of true hurricanes. A memorable example of this was afforded by the cyclone, which passed over Calcutta on the 5th October, 1864. This storm would appear to have commenced at the Andaman islands, on the 2nd October, and then to have passed up the Bay of Bengal, at first slowly, or at the rate of 10 miles an hour; but, quickening its pace, as it approached the mouth of the Ganges, it passed over Kedgeree—five hours before it reached Calcutta—travelling at the rate of from 20 to 25 miles an hour. From this point, the hurricane, still pursuing the same course—a N.E. one—arrived at Kalchee Katta, 90 miles N.E. of Calcutta, at 8 p.m. on the 5th, which may be said to have been the limitation of its range in this direction. That this was a true cyclone, we have proof from two circumstances; the first is, that it was a regular whirlwind; and the next, that it had a central calm. The revolutions of the wind in Calcutta have been recorded, and are shown in the following Table.

Time	Wind	Barometer
6 a.m.	N.E.	29·70
Noon	E.	29·
2 p.m.	E.S.E.	28·25
3 p.m.	S.E.	28·10
4 p.m.	S.W.	28·50
5 p.m.	S.W. by W.	29·30

From this time, the gale gradually subsided, and by midnight had almost entirely ceased: the wind, in the meantime, having veered round to the N.W. From this it will be seen, that the wind did not make a complete circuit; this is to be ascribed to the fact, that Calcutta lay on the outer boundary of the revolving mass. The centre of the hurricane was distant 50 miles from Calcutta; the Alexandra having passed through it—with a calm instead of a storm—between Kedgeree and Balasore, and with the barometer at 27.80. The low state of the barometer, here and at Calcutta, is very remarkable, 28 being hurricane point off the Mauritius. As regards the boundaries of this whirlwind, its diameter was computed at from 150 to 200 miles, with a central calm of 7 or 8 miles. The time during which the storm lasted, in its greatest intensity, was about 5½ hours; and the pressure of the wind, according to the observations made at the Calcutta Observatory, varied from 5 lbs. per square foot to 32 lbs., at the height of the gale. The effects of this storm were disastrous in the extreme. Of 200 ships in the harbour of Calcutta, 12 foundered, and only 8 were uninjured. On shore, the havoc was as great, if not greater. The roof of the Cathedral was blown entirely off, and 92 European houses destroyed; while of the native huts hardly one was left standing. In the environs of Calcutta, the gale would seem to have been equally severe. The station at Barracpore was swept with such destructive force as to prostrate all the barracks and military buildings, the roofs having been first torn off, and blown into the air. Below Calcutta, towards the mouth of the river, the havoc was still greater. At Sangor island, 4,000 souls and 7,000 head of cattle were swept clean away. The ship Alby went down, near here, with 300 coolies on board, only one of whom was saved; and the Phœnix, and two other ships, foundered at the same time. As regards the loss of life in Calcutta, the accounts vary, being set down at 200 Europeans, chiefly sailors, and 1,000 natives. Including all the districts, over which the storm passed, it appears by the Blue Book, subsequently published, that the total number of persons drowned was 90,000; and that the outbreak of cholera, which followed, carried off 75,000 persons; thus making a total mortality of 165,000. The remarkable circumstance attending this storm is, that no such calamity had been witnessed previously; that it passed over the very district in which the epidemic cholera sprang up, and progressed in the same direction.

But unusually severe storms, or cyclones, have not been confined to India; they have been observed in nearly every country previously visited by the epidemic cholera. It is stated in the *Times*, September 18th, 1847, "Our private letters from St. Petersburg, of the 7th inst., state, that that city has been visited with the most terrific storm of wind and rain ever experienced within the memory of the oldest inhabitants. It rained incessantly for 48 hours, whilst the wind blew with intense violence. The result of this visitation was the destruction of above 400 houses. At one period, fears were entertained for the safety of the entire city; and some timid and superstitious persons apprehended that the end of the world was at hand." A more striking example was afforded, in 1859, by what has been termed the "Royal Charter Gale," in which this unfortunate vessel was lost. This gale, which assumed all the characteristics of a true hurricane, or cyclone, passed in a direct line across England, from the Welsh coast to Flamborough Head and Yorkshire; and thence across the North Sea to Norway, having been encountered between Norway and the Shetland Isles. Its regular progression was well marked, having commenced in St. George's Channel, on the 25th October, and reaching

Liverpool at 9 a.m. on the 26th—12 hours after. Its progress, during the rest of its course, was no less regular, having crossed the North Sea on the 28th. That it was a true whirlwind, or cyclone, is undoubted, as the following account will show. "There was a central lull, or calm, extending over an area of 10 or 20 miles; and within this centre the barometer was *lowest*. Around this central space, there were violent winds, which attained a maximum velocity of from 60 to 100 miles an hour; and, in successive *spiral* eddyings, seemed to cross England towards the north-east; the wind blowing from all points of the compass consecutively around the lull; so that, while, at Anglesea, the storm came from the north-north-east, in the Irish channel, it was northerly, and, on the east (coast) of Ireland, it was from the north-west; in the Straits of Dover, it was from the south-west; and, on the east coast, it was easterly—at the *same minute!* In the Bristol Channel, it blew a northerly and westerly gale. Outside of this circuit, the wind became less and less violent, so that on the west coast of Ireland, in Galway and Limerick, there was fine weather, with light winds; while, over nearly all England, the wind was passing in a tempest blowing from all points of the compass, in irregular succession, around a central variable area." * The fall of rain, during this hurricane, amounted to 2.4 inches — an unprecedented quantity for this country. In the following instances, the same facts are apparent. In what was described, by the *Northern Daily Express*, as "one of the fiercest gales that ever swept over the north-east coast" (of England), in December 1867, we have an account of the variation of the compass during the gale. It has been furnished by Mr. Gledhill, of King's Cross, Halifax; and is contained in the following Table, together

* *Tenth Report of the Board of Trade*, 1861.

with the state of the barometer, and the force of the wind.

	Barometer	Temperature	Wind: Mean Hourly Velocity	Wind: Direction
		Deg.	Miles	
Nov. 30, 9 a.m.	29.25	39	2	SSW
12	·10	—	—	—
3 p.m.	28·95	39	7	SSW
Dec. 1, 9 a.m.	·57	51½	9	SW
12	·33	—	12	SW
3 p.m.	·27	49	12	W
6 ,,	·30	41	14	NNW
9 ,,	·45	34	20	NNW
12	·57	29	23	NNW
Dec. 2, 6 a.m.	·75	25	15	NNE
9 ,,	·90	26¾	15	NNE
12	29·15	—	13	NNE
3 p.m.	·27	26	13	NNE

It will be thus seen, that the wind went very nearly round the compass—as far, in fact, as it usually does, unless the centre of the storm passes directly over the place. Another example has been afforded by the storm, which swept over London on the 31st January, 1868; and which was considered as the severest then recorded—more so even than that of the Royal Charter storm. The anemometers, or wind gauges, in that fearful gale registered the force of the hurricane at 29lbs. on the square foot, while that of January, 1868, showed a hurricane force of 35lb. on the square foot, and, in some places, it reached above that range. The wind gathered strength from the W.S.W. on Friday morning, with dark and dreary clouds, the barometer falling rapidly down to 29.38, about midnight; but the temperature of the air was mild. The wind then increased to a gale, and continued during the morning with tremendous force; causing great alarm among the dockmasters at the various metropolitan docks, and owners of the various wharves, for the security of the shipping. From six in the morning (Saturday) till eleven o'clock at noon, there was no abatement; indeed, it became more fierce and terrible in its blast, and at twelve it apparently reached its greatest climax, for a perfect hurricane prevailed. It was at this period, that it indicated the greatest pressure on the anemometers—viz., 35 lb. on the square foot. At Liverpool, the gale was still more severe; and Mr. Hartnup, the astronomer to the Observatory there, states, that the anemometer, which has been erected at the Bidston Observatory, is made to register up to 60 lb. on the square foot, the idea being that no gale would reach that degree of violence. Between eleven and one o'clock, however, the registering pencil was driven far beyond this limit; and Mr. Hartnup calculates that, at several periods, the pressure could not have been less than 70 lb. to 80 lb. on the square foot. "Previous to Saturday last, the severest gale registered by the anemometer, at the Liverpool Observatory, was in December, 1863, when there were three gusts of wind which registered 45 lb. to the square foot." The telegrams received at the meteorological department of the Board of Trade represent the storm to have been pretty general along the coast. At Aberdeen, it blew a gale from W.S.W., with heavy rain. At Leith, there was a perfect storm from the S.W., with rain. At Ardrossan, the wind was S.W., blowing almost a hurricane. At Cape Clear, the wind was W., a terrific gale, with rain. At Liverpool, the wind was W., a terrible gale, with rain. At Holyhead, the wind was W.S.W., a heavy gale and high sea. At Plymouth, the wind was S.W., a terrible gale, with rain. At Portsmouth, the wind was W.S.W., heavy gale, and rain; and, in Scarborough and Shields, the wind was W.S.W., a hurricane, with rain. Even some of the local storms have exhibited the same characteristics, and in a manner still more marked. This was the case with the singular atmospherical disturbance, that occurred at Tuddenham in 1868. According to the *Bury and Norwich Post*, "a narrow strip of country, extending from Thriplow to Cherryhinton, especially suffered. At Thriplow, a whirlwind passed through the centre of the village from south to north, completely devastating everything in its path; its ravages were most apparent at the National Schools, and on the property of Henry Perkins, Esq. In the schoolroom, which is quite new, upwards of sixty children were assembled, when both ends of the room were blown outwards, and the materials scattered in all directions. At the same instant, the trees surrounding the building were torn up by the roots. At Mr. Perkins's, four magnificent elms were rooted up, and a large spruce fir was twisted like a corkscrew. In all, upwards of 400 trees were blown over. The whirlwind also swept over an off-farm of Mr. Ellis's, tearing the buildings to pieces. In passing from Little to Great Shelford it crossed the river, on the banks of which was a plantation of about sixty trees, belonging to Mr. P. Grain, which were entirely swept away. A little further on is another small plantation, divided by the Great Eastern Railway. Through the opening the storm seems to have passed, just touching one side of the passage, and breaking off a fir, which it carried about 100 yards, and dropped on the road on the bridge over the railway. The whirlwind had the appearance of an immense column of dense smoke, mixed with leaves, dirt, and branches of trees. It was about 100 yards across, appeared to reach from the earth to the clouds, and made as much noise as a heavily laden train at full speed."

That the storms of the present epoch have been gradually increasing in frequency and intensity, we may learn, without entering into further details, merely by a reference to the returns of the Registrar-General. From these we find, that there were three deaths from lightning, registered in England, in 1863; six in 1864; twenty in 1865, and nineteen in 1866—48 in all. This gives an average of 12 each year. During the next four years—1865-8—the number killed was 67, being an average of between 16 and 17. Could we have carried the comparison back 30, 40 or more years, the difference would have been still greater and more striking, death by lightning being extremely rare during the first half of this century. It may also be remarked, that many of these thunder-storms have occurred at unusual periods of the year—in winter rather than in summer—as was the case with the terrific storm which commenced at Cork, in Jan. 1873, and thence extended across the Channel to Birmingham and Derby, where its greatest violence was expended.

Having thus narrated the particulars of some of the atmospherical phenomena, that have been observed at the present epoch, we will now inquire into the cosmical phenomena that occurred, subsequently to the advent of the epidemic cholera. Commencing with that part of the world in which this disease first made its appearance, we find that, in July 1817, a slight shock was felt in Calcutta, and at Madras; and more severe ones, in Oct., at Ganjam, Berhampore, Benares, Cawnpore, and in the camp of the central division of the Bengal army. No particular convulsion appears to have been experienced again until 1819, when an earthquake—a phenomenon, to use the words of a writer in the *Madras Courier*, very unusual, we might we believe almost say unprecedented, in this part of India—occurred on the 16th of June in various parts of the Peninsula; but more particularly in Cutch, which appears to have been the centre of the shock. So little known is such a visitation, observes the above authority, that the moonsif quoted his Hindoo shasters as foretelling that an earthquake would *some time* happen. The effects of the shock in Bhooj are thus described by the same writer. "After two slight motions, that lifted the chairs, the tower near which Capt. Macmurdo was sitting, after heaving and rolling in a most awful degree, gave way at the bottom, and crumbling down buried guns and carriages in the rubbish; a moment after, the towers and curtains of the fort wall, and upwards of 15,000 houses, were reduced to ruins, and 2,000 persons buried beneath." This shock lasted about two minutes, but many slight concussions were also experienced during the night. On the next day, the earth was frequently in motion, until about a quarter to 10, when a severe shock, that lasted nearly 50 seconds, was experienced, and brought down a number of shattered buildings. Until the beginning of August, no day passed without some slight shocks; subsequently, they became less frequent, only occurring at uncertain periods of many days interval, until the 23rd of November, which appears to have been the last distinct one. The shock extended in a direction from north-west to south-east; and the utmost limits, within which the earthquake was felt, were, as far as it was known, Catmandoo in the north, Pondicherry in the south, Calcutta to the east, and the mountains of Belloochistan to the west. Although the appearance of the country in Cutch shows, that it has suffered, at some period, from convulsions of this nature; and although there are strong signs of volcanic matter thickly scattered over its surface, still, there does not exist *even a tradition* of an earthquake of any violence having occurred there before. The lofty minarets of Ahcmedabad, which were thrown down, had stood something more than four centuries: an evidence that no such convulsion had taken place there within that period of time." Two more shocks were felt in Calcutta on the 17th and 18th June, and, on the 20th, not only in the capital, but, also, at Chuna, Muttra, Mirzapore, Surat, and many other places. In 1820, there was another shock at Bhooj: and more severe and general ones in 1827 and 1828. At the commencement of the former year, many houses were destroyed in Hyderabad, and slight shocks were felt at Calcutta, Burdwar, and Vizagapatam, in the same month.* On the 29th October, the valley of Nepaul was convulsed by an earthquake, the shocks being from south to north. A severe shock was also felt in Sylhet, while the fort of Kolitaran was destroyed by the same convulsion, 1,000 persons being buried beneath the ruins.† This was followed, in 1834, by what was termed the great Nepaul earthquake. It was felt throughout the Punjaub, and even the greater part of central India. Its point of departure would seem to have been Katmandoo, if the time stated by different observers be correct. It was more severe in the north than in the south, or at Calcutta; where it was felt 37 minutes after the shock at Katmandoo. Forty shocks were counted in some places. At Bhatgaun, to the east of Katmandoo, 1,000 houses were thrown down, and 300 people killed. We hear of no other concussion until 1842, when a severe one occurred in the north-western parts of India, at Delhi, Missouri, Simla, &c. The next, that has been recorded, was in 1873, on the Sindh frontier. The full force of the shock appears to have fallen on a town called Lehrie, in which nearly every house was destroyed, and 500 persons buried in the ruins.

The same phenomenon was observed along the route taken by the epidemic cholera, from India to Europe. Although some slight concussions had been felt in Bombay in 1821, they did not extend beyond. On the 11th June,

* *Asiatic Journal.* † *Madras Government Gazette.*

1824, however, a concussion is reported to have occurred in the south-west of Persia, and another on the 24th of the same month. The shock must have been a very severe one, for an Armenian clergyman, writing to a friend at Calcutta, states, that Kazeroon, Feruzabad, and the surrounding villages, suffered the same calamity; while a part of the cities of Shiraz and Kazeroon was destroyed, and 200 persons, in Shiraz alone, buried in the ruins. Another shock was felt in Shiraz the following year. Previously to this, or in 1822, there had been a severe concussion in Asia Minor. Mr. Barker, the British Consul, in a communication to the Levant Company states, that Aleppo, Antioch, every village and every cottage in the Pashalic, and some towns in the adjoining ones, were, in 10 or 12 minutes, entirely ruined by an earthquake, and had become a heap of stones and rubbish; while, on the lowest computation, 20,000 human beings, about a tenth part of the population, were destroyed, and an equal number maimed or wounded." Slight shocks continued to be felt in the same spot until the 9th October, when they entirely ceased. The shocks were from south to north not from east to west, and did not belong, therefore, to the old volcanic region, or that of the Mediterranean. A still more disastrous concussion occurred in Syria, in 1836, whole villages having been swallowed up, and a large part of the population having perished in some of the towns. At Saphiet, 3,500 were killed out of only 4,000 inhabitants. There was a concussion the following year, in Asia Minor; but it does not appear to have been a violent or destructive one. As may be remembered, the epidemic cholera did not progress any further in this direction; its principal route being by the northeast of Persia, the Caspian Sea, and the Caucasus. Turning to the phenomena observed along this line, we find that, in 1820, a concussion occurred at Tiflis, in Georgia; and at the same time, or in the same year, at Stavropol, in the Caucasus, as, also, in the Crimea. There was another violent concussion in the Caucasus the following year; and it is stated, that the effects of this earthquake were felt over the whole of the Turkish provinces. In 1829, Georgia was again visited, the concussion extending to Bucharest; and from Transylvania to Kieff, in Russia. In 1830, a concussion occurred at Astrakan, shortly after the outbreak there of cholera; and, in the following year, at Bucharest and Moldavia. In the next, there was another concussion at Tiflis, and, in 1834, at Anapa, on the borders of the Black Sea, and in Bessarabia. In 1836, many places in the Aural were visited by an earthquake, that was felt in Dalmatia. A second concussion occurred in the Aural the following year; and, in 1838, at Baleki, near Baku, in the Caucasus. Another concussion was felt in 1841 in Georgia and in the Aural; and, lastly, in January 1872, the city of Shamachi, in the Caucasus, was totally destroyed by a succession of earthquakes, many lives being lost at the same time. We thus find, that terrestrial commotions were constantly observed along the route pursued by the epidemic cholera from the north of India to the southern part of Russia. That they belong to the new, not the old, volcanic line will be evident from the fact, that they have progressed in a direction from north to south, not from east to west as was invariably the case in the Mediterranean region. As regards the route which the epidemic took across the Continent of Europe, we find, that several shocks of earthquake were felt in Hungary in 1822, and at Gratz, in Styria, in 1839; but none have been recorded in the north of Europe until 1831, when several slight ones occurred, as, also, along the banks of the Rhine. There was a concussion at Darmstadt in January

1860, the shock lasting twelve minutes. The bells were set ringing, plates were thrown down, and the plaster detached from the walls and ceilings. Another was felt at Cologne at the end of the year. No other concussion appears to have been recorded, in this part of the world, until 1872, when, in a letter dated Berlin, March 6th of the same year, it is stated: "Intelligence received here, almost simultaneously, from Dresden, Pirna, Schandon, Chemnitz, Bollenbach, Weimar and Rudalstadt, announces, that shocks of earthquakes were felt in these towns between 3 and 4 o'clock this afternoon. They continued to recur during an hour, and, in some cases, for several hours." On the next day, shocks were also felt in Berlin, and in various parts of central Germany.

Passing from the Continent to England, we shall find, that a rather smart shock was felt in Cornwall the end of 1859; and another the beginning of 1860. A more general and severe one occurred in October, 1863. It was principally felt over the western or south-western part of England, and embraced the following towns, among others:—Bath, Banbury, Birmingham, Bridgwater, Bristol, Burton-upon-Trent, Cardiff, Cheltenham, Clevedon, Congleton, Derby, Exeter, Gloucester, Hemel Hempstead, Hereford, Kidderminster, Leicester, Leominster, Liverpool, Manchester, Market-Harborough, Newport, Nottingham, Portishead, Reading, Sheffield, Shrewsbury, Slough, Stourbridge, Swansea, Taunton, Walsall, Wolverhampton, Worcester, Wordsley, etc. One of the correspondents of a Birmingham paper says, that at the time of the shock he was lying in bed awake, when he felt a swaying, rocking, or undulatory motion, inducing nausea. Another correspondent says, the motion, which was very palpable, appeared more like an upheaving than an oscillatory movement; while a third felt a rocking under his bed, and experienced a sensation as of standing upon the platform of a railway station while an express train is passing. At Wordsley the shock appears to have been remarkably severe. The Rev. R. B. Girdlestone writes as follows to a local paper:—"Last night I was awakened, about 3.15, by a shock which made the whole house quiver; the bed shook violently, the windows rattled, and all the furniture seemed to shiver. The effects of the first shock had hardly subsided, when a second followed it, with a sound as of a *heavy explosion* beneath the cellars, which made the house shake from the bottom to the top." At Derby, Worcester, Hereford, and Gloucester, the subterranean noises and the shakings of the earth were also severe. At Taunton, the utmost alarm was created by the earthquake and the noise, which accompanied it; and a large number of persons betook themselves to the streets and open spaces to escape being crushed by the fall of buildings, which they anticipated. The trembling of the earth and the noise were felt with equal intensity in Exeter, and along the South Devon Coast, causing everywhere considerable alarm. As regards the direction of the earthquake, it would appear to have been from S.W. to N.E., or, rather, from N.E. to S.W.—the time of the shock at Derby and Clapham being 3.15 and 3.20 a.m., and 3.30 in places to the S.W. Another shock was experienced in February, 1864, but it was very limited in its range, being confined to North Lancashire. The year 1868 was ushered in by a smart shock of an earthquake in Somersetshire. It was felt principally in Langport, Taunton, and Bridgwater, but did not extend beyond. A more severe concussion occurred in October of the same year. Its effects were felt on both sides of the Severn, and over a considerable tract of country; but South Wales would appear to have been the chief seat of the concussion. The following are some of the principal towns in which the shocks were experienced. Merthyr, Brecon, Llandelo Fawn, Monmouth, Gloucester, and other places in the county; Worcester, and the towns and villages on the western side of the Severn, Warwick, Leamington, Swansea, Bristol, Exeter, Bridgwater, Barnstaple, Taunton, &c. Like the earthquake of 1863, the direction of the wave was from S.W. to N.E. or N.E. to S.W. Early in January 1869, a slight shock of an earthquake occurred in Suffolk. It was felt principally at Elmswell near Bury, and at many places between this town and Stowmarket, but does not appear to have extended beyond these points. In the following March, a rather severe shock was experienced over a considerable area of the middle and eastern parts of the county of Lancashire. On the following day, two concussions, at intervals of some hours, occurred in East Yorkshire. They were almost confined to the limestone belt, or wold country, and do not appear to have been felt on the north, or moorside of the great valley. The same phenomenon was observed in the earthquake that occurred there in 1863. In January 1871, several slight shocks were felt in Sheffield, during the occurrence of a thunder storm, and, in March, a more general one—the severest, perhaps, that has been experienced in England at this epoch. Lancashire may be said to have been the centre of the concussion, but the shock was felt along a line which extended from Altringham in Cheshire to Sunderland. At Ulverstone and Lancaster, furniture was thrown over in some houses; and at Kendal, doors and windows were violently shaken, and small articles thrown to the ground. In some instances, the beds were so violently shaken as to make the occupants believe some one was underneath.

This completes the list of terrestrial commotions. It is not a very long one, nor have the concussions been very frequent, or very severe: compared with those that occurred at the former pestilential epoch, they are altogether insignificant. But this, so far from militating against the theory, is precisely in accordance with it. If, as was inferred, a new volcanic line has been formed across the countries in which these effects occurred, we could hardly expect that the manifestations of that action would be either very frequent or very marked at present. It takes, as we have seen in the case of the volcanic band of the Mediterranean, many centuries before the process, which is termed volcanic action, becomes completed. Besides, if diseases, as has been inferred, be the first product of the volcanic process; and if they prevail, in general, anterior to the concussions, these phenomena would not, and could not, be observed to any extent at the present time—the commencement alike of a new volcanic line and of a new pestilential epoch. When, however, in addition to the morbid effects in the organic kingdom, we observe concussions to commence in some new region—no matter how slight they may be—we may not only conclude, that a new volcanic line is being formed, but, also, that these phenomena will continue to increase, both in frequency and intensity, in future. How long this will continue it is impossible to say: some centuries, at least, if we are to judge from other examples, unless the world should be destroyed previously, or unless the new volcanic line, as sometimes happens, should be lost in the old one. We have had, in fact, an example of this already in this very region. As may be remembered, the epidemic cholera reached the southern shore of the Mediterranean, by the way of Asia Minor, in 1823; and, by Egypt, in 1831; but it has never extended beyond, in this direction, from that day to the present. It was by another and different route—by Persia and the defiles of the Caucasus—that Europe was invaded by this modern pest. As there are no volcanos, no open ducts offering a communication from the interior to the exterior, in this situation; and as all the effects referrible to volcanic action have been manifested, in Europe and in America as well as in Asia, from that time to the present, it is to be feared, that the same result will not be observed on this part of the line as on the shores of the Mediterranean. In that case, we must look forward to a periodical return of all the diseases previously enumerated, as well as all the other effects referrible to the same cause, as long as this cause continues in operation. More than this, we may also infer, that other diseases, not now prevalent, or previously observed at this epoch, will hereafter make their appearance in Europe. One of these is the plague. My reasons for drawing this conclusion are the following. In the first place, I consider the epidemic cholera to be the forerunner of the plague; for a somewhat similar disease prevailed, previously to the first appearance of the plague in Europe, in the 6th century. It was called the cardiac disease, a name bestowed on it by the vulgar not the learned. The attack, according to the account that has been given of it, commenced with a rigor, and numbness of the limbs; the pulse became frequent, small, and weak: then unequal, fluttering, and finally extinct. A clammy, offensive, perspiration broke out over the body; and was so profuse, that it ran, like water, through the bed clothes. Hence the disease was sometimes called *diaphoresis*. The patients were restless: the breathing was difficult, with a sense of suffocation, and oppression at the chest; the voice tremulous and thin, or low (*vox colerica*); the body cold, the countenance pale; eyes sunk in the socket; *blueness* of the hands and feet, and around the eyes, with wrinkled skin. Some had convulsions, and a few became unconscious, but the majority retained possession of their faculties until the last. No mention is made of vomiting or purging: had there been, we should have called the affection, Asiatic cholera—the majority of the other symptoms being identical with this modern scourge. Some writers, however, refer to a disease,—either this or some other—attended both by vomiting and purging; and Galen, A.D. 131, gives a description of one which presented a great similarity to the epidemic cholera. Celius Aurelianus, also, a few years later, speaks of *serous* cholera, attended by blackness of the countenance and consecutive fever. This disease, the cardiac, prevailed for about 500 years, from 300 B.C. to A.D. 200. Subsequently to this, the disease assumed a more characteristic form, or, else, gave place to one almost identical with the epidemic cholera. It has been described by Paulus Ægineta, A.D. 700, and by Rhazes, of Bagdad, A.D. 900. Deguignes, also, in his history of the Huns, speaks of an epidemic of cholera, which, in A.D. 1031, proceeded from India through the provinces of Ghuzni, Khorassan, Armenia, and Syria, to Constantinople. Drasche also refers to some Arabian writings, that speak of an epidemic of cholera, which, proceeding from India, through Egypt, Nubia, and Abyssinia, was lost in the deserts of Africa.* But we hear of no cholera epidemics after this: the disease, like many others, would seem to have merged into the reigning one, or the plague, as the present epidemic will no doubt do. These conclusions are strengthened and confirmed by certain facts, that have been presented to our notice since the commencement of the present pestilential epoch.

As may be remembered, the plague has been confined,

* *Die epidemische Cholera.* Vienna, 1860.

since the middle of last century, to the eastern shore of the Mediterranean, or Turkey, Asia Minor, and Egypt; while no severe visitation has been observed there since 1835, and only a mild one in 1844. When it did spread, however, and particularly from Asia to Europe, it was always in a direction from east to west. Bearing these facts in mind, we shall be enabled to arrive at some important conclusions. A severe and fatal form of fever, described by Dr. Glen as a "bubonic febrile malady," and termed "The Bombay Plague," appeared in that province in 1818—the year after the advent of the epidemic cholera. A similar disease prevailed about the same time, although not extensively, in Cutch, Kattywar, and Sindh, and continued until 1820. In 1823, a disease, now known to be plague, broke out in the Himalaya mountains, in the district of Gahrwál, contiguous to Kumaun, and again in 1834-5. In 1836, it appeared at Pali—hence termed the Pal plague—situated in Marwar, Rajputana, and prevailed in several other places in this province. The disease re-appeared in 1849-50, 1860, and 1876-7, a special report of the last outbreak having been made by Mr. C. Planck, who investigated the nature of the disease. He remarks: "When first brought into contact with the disease, I was inclined to think, as Dr. Rennie had done, that it was a form of rapidly fatal *typhus*, more especially as the characteristic buboes of plague had not, as described to me, been observed in the cases first brought under my notice at Balt and Bintola. A further acquaintance with the disease, its symptoms and peculiarities, soon convinced me, that it was identical with the disease *pestis* of medical writers, and nameable in English only as plague." * Mr. Planck further inferred, that the previous outbreaks were

* Ninth Annual Report of the Sanitary Commissioner of the North-Western Provinces.

those of plague from "the fact, that the people everywhere in Kumaun and Gahrwál have a specific name for the disease, calling it 'Gola' or 'Phutkia,' both words meaning *bubo!*" The disease is sometimes called Máhá-mari (pestilence), but this term is applied to cholera as well as plague. As regards the cause of the outbreaks, Mr. Planck remarks: "The history of the plague of Gahrwál and Kumaun, as yet recorded, shows it to be the result of *endemic* influence, arising from conditions, or agencies, peculiar to locality." Nor could it have been propagated by infection after it had arisen; the limitation of range of the disease precluding such an idea. Thus, in 1834-35, a total of 633 deaths were recorded as having happened in villages widely separated in Gahrwál: and a total of 113 deaths as having occurred in nine villages in 1849-50. In the outbreak of 1851-52, there were 567 deaths in seventy-seven villages. What the number of villages in this district is, has not been stated, but, in Kumaun, there is a total of 6,346 villages: yet, during the prevalence of plague in 1876-77 only forty-one villages were attacked, the deaths in which were 277. "These villages," adds Mr. Planck, "are widely separated in different parts of Kumaun, so widely, that they may fairly be considered as scattered throughout its northern half." The limitation of range, even in the affected villages, was no less remarkable: "for it will be seen that, as a rule, the prevalence, even in the village itself, is confined to *one* house or one terrace or one portion of the village." A circumstance worthy of note, and recorded by the same writer, is the fact, that rats were frequently found dead in the houses of families *about to suffer* from an outbreak of plague—a result that has been before observed in other epidemics. These outbreaks are very remarkable, and worthy of special notice, there being no evidence of the prevalence of plague in India for many centuries before.

We hear nothing more of the plague after this, until 1853, when it suddenly appeared on one of the two routes —viz., the Red Sea and the Persian Gulf—by which the epidemic cholera spread after leaving India. This outbreak occurred among the "Beni Sheir" tribe, inhabiting the table-land of the Assyr country, situated about four days' march from Mecca to the south of that city. This visitation is no less remarkable than the former, having appeared on the exact line of the epidemic cholera, and being, evidently, unconnected with the cause productive of plague, during the last pestilential epoch. There was another visitation here in 1874, but the disease, in both instances, was confined to this part of Arabia, and did not spread beyond. There is no account of the appearance of plague along the other route from 1832, when a severe outbreak occurred in Persia, until 1863. In this year, what was then considered to be, an unusual disease broke out in Persian Kurdistan, in the district of Maku. Dr. Rossi, who was sent by the Ottoman Government to investigate its nature, states, that the disease was the true bubonic plague; but it does not appear to have been very fatal, while the limits of the epidemic were very circumscribed. Four years after this, or in 1867, the plague again made its appearance in this part of the world, among the Arabs inhabiting the Hinditch marshes, situated on the west bank of the lower Euphrates. The inhabitants live in villages on the islets scattered among these marshes; but only five of these villages were attacked, the deaths in which amounted to 300 out of 1,000 residents. The total population of the district is 50,000. After another interval of four years, the plague re-appeared in Persian Kurdistan in the autumn of 1870;

not among marshes, but on an elevated table-land to the south-east of Lake Urumiah. The disease is believed to have originated in a hamlet, situated at an altitude of 6,000 feet, and which, at the time, only contained six families. It was during the winter of 1870-71, when deep snow fell, and, the villages being isolated, intercourse with the surrounding inhabitants became impossible, that the disease prevailed to the greatest extent. When the spring returned, and communications with the surrounding villages and districts were resumed, the disease did not spread excepting to a very limited extent, and died out before the end of the year. Of 14 villages invaded, containing 1,326 inhabitants, 1,120 were attacked; of whom 891 died and 229 recovered. In 1873, there was another visitation, but, this time, the disease appeared among the marshes on the east side of the Euphrates, nearly opposite to the Hinditch marshes. This outbreak was investigated by Dr. Cassaldi, by order of the Ottoman Board of Health; and he has, in his Report,* drawn particular attention to the limitation of range of the disease under circumstances the most favourable, apparently, for its propagation. The population of this district was reckoned, by Dr. Cassaldi, at about 80,000, and the deaths from plague at 4,000. Of these, 2,000 died in Dagarra, and the surrounding villages, with a population estimated at 35,000. But at Kerbela, there were only *three* deaths out of a population of 10,000; while at Humel-Bahrour, with a population of 1,500, there was not a single case, although there were 8 deaths among a body of police, who had contracted the disease elsewhere. In 1874-5, another outbreak occurred—in Mesopotamia—the particulars of which have been given by Surgeon-Major Colvill, attached to the Embassy at Bagdad, in a letter

* *La Peste dans l'Irak-Arabi.* Constantinople. 1875.

addressed to the Consul-General there. Mr. Colvill states, that "a *triangle*, with an angle at Kut-il-Amarah on the Tigris, another at Shinefeah, and a third at Sook-il-Shiock, will include the infected district. By a reference to the map it will be seen, that the area this year was more extended than that at the two previous visitations; as, also, that it embraced a small portion only of the previous ones, and extended much farther south."* Either the disease had not entirely subsided, or, else, there was a return of it at the end of 1875; as it took head at that period, and continued to prevail during the following year, as, also, in 1877. The plague, during this visitation, not only occupied a much larger area than before, embracing all the three previous areas, but it extended further north, as far as Bagdad. It was this part of the area, extending from Hillah, that suffered most during this visitation. The disease gradually increased in intensity from the beginning of 1876, was most fatal and most general in April, gradually declined in May, and disappeared in July, when the temperature was the highest. It returned, however, in the following October, and broke out in the district of Abu Graib, 50 miles above Musseib, a point to the north higher than the disease had previously attained. The epidemic continued to prevail, although to a less extent than in the previous year, until the following June, when it subsided altogether. During these two years, 20,000 persons, it is supposed, perished. Contemporaneously with the above, was an outbreak of plague in Khuzistan, south-western Persia. It commenced in March 1876, in a village about 10 miles to the north of Shuster, the former capital of this province,† and then

* This letter has been inserted in the Blue Book, on the Plague, issued by the Government Local Board, 1879.

† Shuster having been nearly depopulated, during the visitation of plague, in 1832, the capital was transferred to Dizful, thirty miles distant.

spread to this town, and the surrounding district. The visitation was not a severe one, the total mortality, in the district, not being more than 2,500. At the end of the same year, or in December 1876, plague appeared in two villages, in the north of Persia, about 35 leagues from the south-east angle of the Caspian sea. These villages are about four leagues to the south of Sharoud, and two miles from the route between Teheran and Meshed, and are situated in a valley at an elevation of about 3,000 feet. The outbreak did not continue long, the disease having disappeared at the end of January 1877.* In March following the plague appeared at Resht, or Rescht, at the north-western corner of the Caspian sea. Like Shuster, this town had been nearly depopulated by a former visitation of this disease, and at the same period, or, in 1832. The epidemic presented a much milder type on the present occasion, the deaths having been calculated at 4,000 in Resht and the surrounding districts: the population in the town itself being about 20,000.

Such is a brief history of the outbreaks of plague in these regions, and during the present pestilential epoch. As, however, all these outbreaks occurred in the former seats of plague, it may be supposed, that no inference can be drawn from their occurrence, as regards its re-appearance hereafter. When, however, we find, that plague has appeared in the north of India, where alone we should expect to find it, for this disease cannot exist at a very elevated temperature ; † and when we also find, that all the

* Dr. Tholozan *Comptes Rendus de l'Académie des Sciences.* Vol. 85, p. 432. (1877.)

† Dr. Dickson, Physician to the British Embassy in Constantinople, states, that the plague in Mesopotamia commenced in the winter, reached its acme of intensity in the spring, and died out suddenly in summer, when the great heat declared

outbreaks, previously described, took place along the lines of route of the epidemic cholera, the idea at once crosses the mind, that the cause is the same as that productive of the latter disease. This inference will be strengthened when we find, that the disease has progressed in a different direction to what it did formerly, or during the last pestilential epoch. Then, it travelled from east to west; now, its progress has hitherto been from south to north. This has been more particularly the case during the last winter, 1878-79, when the disease, by a sudden spring, passed directly across, or *under*, the Caspian sea, and invaded the province of Astrakan. Not that this was the first appearance of the plague in Russia: Dr. Cassaldi, who was sent to Resht by the Ottoman Government, on the outbreak of plague there, states, that he was informed by M. Schulzewski, Chancellor of the Russian Consulate-General at Tabriz, that a disease resembling typhus—*i.e.*, the plague, being accompanied by buboes—had prevailed at Baku, on the northern shore of the Caspian sea, in January 1877. There were seven deaths in the course of three days, in two houses, among whom was the mother of M. Schulzewski. Having thus passed beyond the old plague area into a new region, and by the same route, in fact, by the very *line* of the earth's surface as that pursued by the epidemic cholera, we may reasonably conclude, that it will hereafter traverse the remaining

itself. "During the prevalence of the plague the thermometer ranged between 5 and 30 degrees (C); and when it rose to 30° (86° F.) the disease had reached its maximum of intensity. As the temperature increased from 30° to 45° (86° to 113° F.) the epidemic began to diminish, and as soon as the thermometer got up to 45° (113° F.) *it ceased abruptly.*" (*On the Characters of Epidemic Plague in Mesopotamia. Loc. cit.*) In Egypt, also, as previously stated, plague invariably ceased on the accession of warm weather—in the same month, and almost on the same day.

portion of this morbific line. No other conclusion, in fact, can be drawn on the subject. How long it may take to traverse the whole of the remaining portion of the route, from the Caspian sea to the northern part of America, time alone can tell. There are, however, indications of its speedy arrival in the north of Russia. As may be remembered, a case occurred in St. Petersburg, which gave rise to some discussion, as to whether it was plague or not. That it was, there can be little doubt, for these sporadic cases, which sometimes present the disease in a slightly modified form, and hence escape detection, are invariably found to precede, for some months, or it may be years, the advent or the return of epidemic and pestilential diseases. Examples of this have been already given with respect to the plague; and others have been recorded in the First Part of this Work, in the chapter on the Propagation of Cholera. Be this as it may, of one thing we may be certain, that pestilential diseases will continue to prevail, for a longer or shorter period—some centuries in all probability—in all the countries hitherto invaded by the epidemic cholera. To these we may add, blight, or pestilence, in the vegetable creation, with its attendant, famine; great atmospherical vicissitudes, storms, hurricanes, floods, inundations, earthquakes, and all the calamities that follow in the train of these events. That all these phenomena will recur, again and again, during future ages, we shall be bound to conclude, not only from analogy, but, also, from the fact, that the whole of them have prevailed, to a greater or less extent, since the advent of the epidemic cholera, and along the line taken by this new epidemic. Such, then, is the future destiny of the inhabitants of Asia, of Europe, and of America—a destiny from which there can be no escape, for there is no earthly power, there are no human means, that can prevent a recurrence of these evils for a single moment. All that can be done, by poor finite man, is to mitigate the effects when they arise; and this applies to diseases the same as the physical evils now referred to. Those who maintain the contrary, and who talk of a sanitary millennium hereafter, are not only deceiving themselves but they are deceiving the public, by holding out expectations and promises that never will be, never can be, realised. There will be no sanitary millennium, until the real millennium arrives.

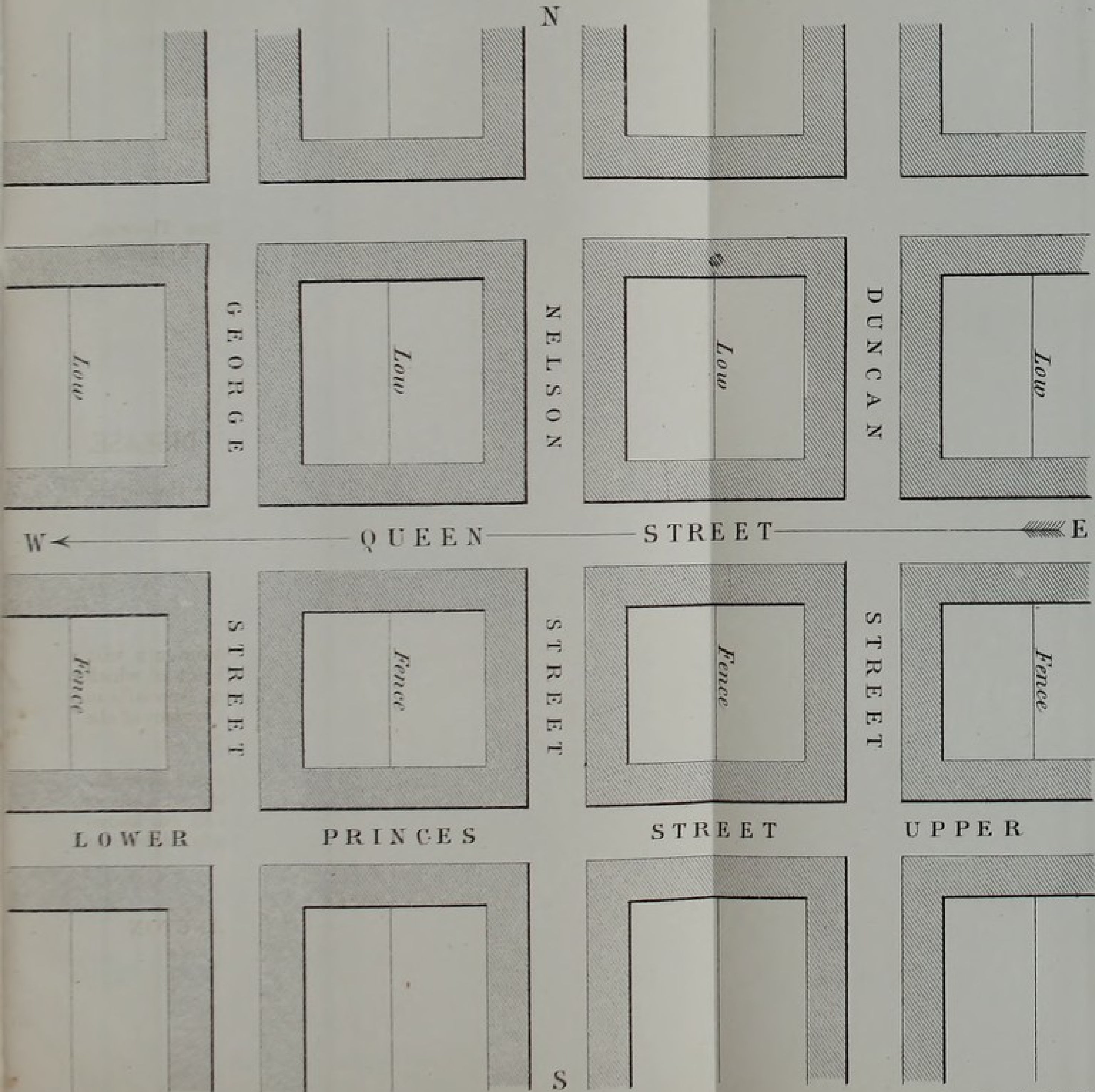
NOTE.—As bearing on a subject previously discussed, and confirmative of the conclusions then drawn, the following extract on the "Fog Fatality in London" has been added. "If," remarks the Editor of the *British Medical Journal*, "one or two weeks during the cholera epidemic of 1846 and 1854 be excepted, the recorded mortality in London, last week, was higher than it has been any time during the past 40 years of civil registration. No fewer than 3,376 deaths were registered within the metropolis, during the week ending last Sunday; showing an excess of 1,657 upon the average number in the corresponding week of the last ten years. . . The deaths registered in London showed an increase of 54 per cent. upon the number returned in the preceding week. The increase of mortality varied considerably in different parts of London; it was 32 per cent. in the west; 48 per cent. in the north; 51 per cent. in the south; 64 per cent. in the central, and 83 per cent. in the east, groups of registration districts. The excess of mortality due to the cold and fog was naturally largest among elderly persons; it was smallest among infants, and increased steadily with age. . . The excess of mortality was mainly referred to diseases of the respiratory organs, which caused 1,557 deaths last week, against 559 and 757 in the two preceding weeks, showing an excess of 1,118 upon the corrected weekly averages. . . . The terrible slaughter caused by the recent London fogs should suggest a scientific inquiry as to how far the poisonous and suffocating qualities of these fogs—so different from most fogs out of London—arise from causes which should be, if they are not, within the control of an efficient sanitary authority. It is smoke that makes the London fog so mischievous; and bearing in mind the disaster of last week, it is worth inquiring whether something cannot be done to mitigate the main cause of this remarkable mortality."—(Feb. 14, 1880). The only way in which the smoke can be injurious, is by preventing the fog from being dissipated in the surrounding atmosphere, as speedily as in other situations. Smoke, *per se*, is not injurious, as shown by the fact, that London and manufacturing towns, in which large quantities of smoke are evolved, have been less severely visited by the epidemic cholera than other towns. Nor can the increased mortality be referred to cold; as, in 19 provincial towns, where, of course, the cold was as great, the rate did not exceed 26.3 per thousand. It is, therefore, the fog, and the fog alone, that was productive of these dire results.

C. A. Macintosh, Printer, Great New Street, London, E.C.

DIAGRAM.

SKETCH OF THE PRINCIPAL STREETS IN THE TOWN OF PORT OF SPAIN, TRINIDAD.

See page 9.



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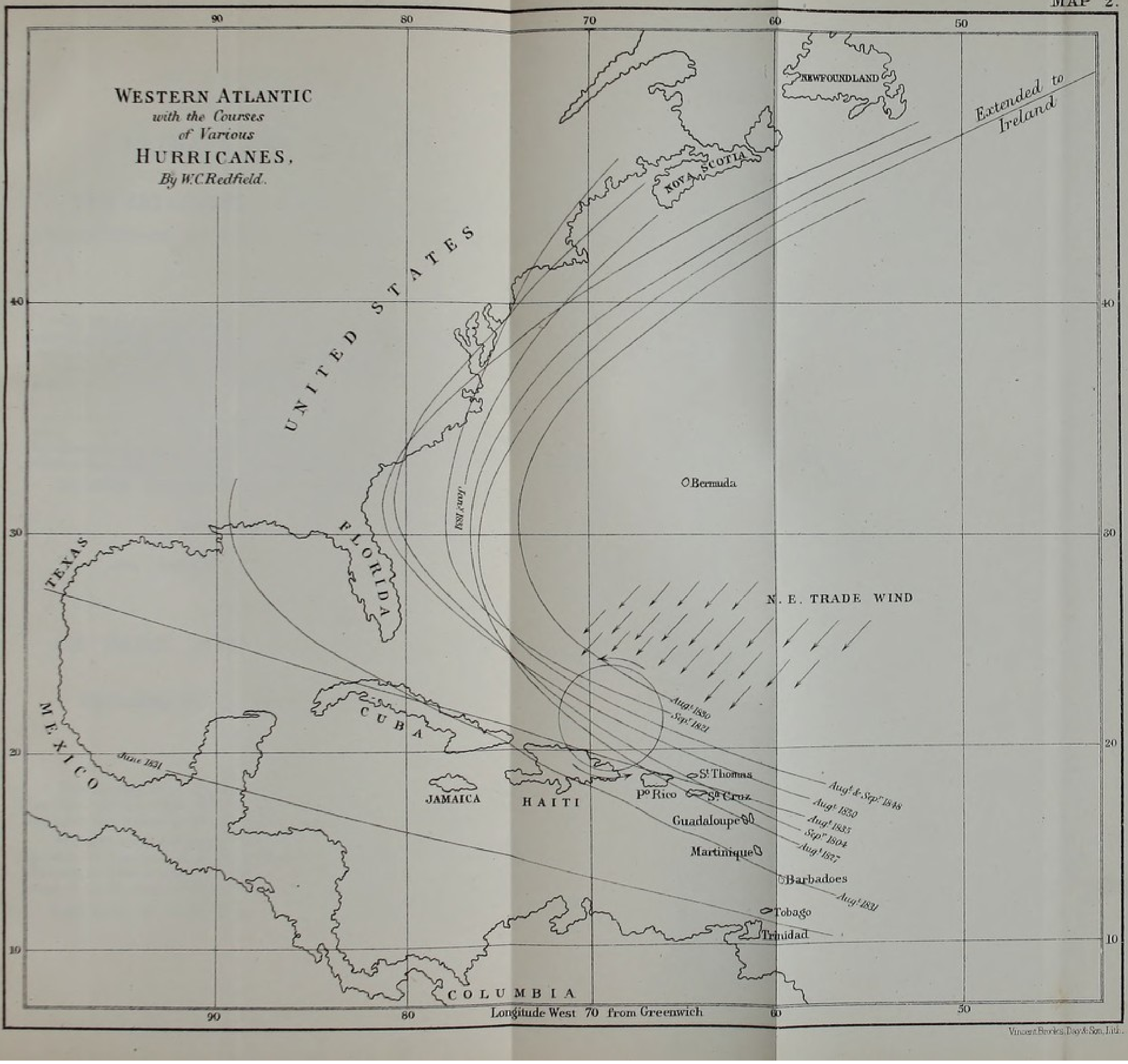
MAP 1.

Longitude West from Greenwich

Longitude East from Greenwich.


MAP 2.
WESTERN ATLANTIC
with the Courses
of Various
HURRICANES.
By W.C.Redfield.
UNITED STATES
NOVA SCOTIA
NEWFOUNDLAND
Extended to Ireland
FLORIDA
TEXAS
MEXICO
CUBA
JAMAICA
HAITI
Bermuda
N. E. TRADE WIND
Sepr. 1821
Aug. 1830
St. Thomas
Po Rico
St. Cruz
Guadaloupe
Martinique
Barbadoes
Tobago
Trinidad
COLUMBIA
June 1831
Augt & Sepr. 1848
Augt. 1830
Augt. 1835
Sepr. 1804
Augt. 1837
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Longitude West 70 from Greenwich
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