AN ENQUIRY
INTO THE
ORIGIN AND INTIMATE NATURE
OF
MALARIA

BY

THOMAS WILSON

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AN ENQUIRY INTO THE ORIGIN AND INTIMATE NATURE OF MALARIA.

By THOMAS WILSON,
CHEVALIER DE L’ORDRE DU LION NEERLANDAIS.

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TO

M. ROCHUSSEN,

MINISTER OF COLONIES AT THE HAGUE.

Sir,—

I have taken the liberty of dedicating this little work to you. It treats of a subject on which I have made many experiments and collected many observations in Belgium and in Holland. I have carefully weighed the conflicting evidence of some distinguished observers, and the conclusion arrived at is, that this conflict has arisen partly from a want of due care in making the observations, partly from the extreme difficulty accompanying all inquiries in which physiology and pathology, health and disease, are necessarily involved.

In the course of my memoir I have endeavoured to do justice to Holland, esteeming it to be the most remarkable country in the world. I cannot find in the history of any other nation proofs so clear of the beneficial effects of indomitable industry, directed by intelligence, over the welfare and destinies of a people; nowhere do I find evidence so convincing of the great results flowing from the application of practical science to the wants of a people; nowhere do I find to the same extent a sound commercial and political economy, first developed and acted on in Holland, lead so directly to the civilization and welfare of a nation. Those great principles which other nations and other races discussed theoretically and elaborated into systems, the nation of which you are a distinguished citizen, discovered, adopted, applied, and enforced. To Holland, as a nation, belongs eminently the character of practical. Whilst other nations left uncultivated as they found them, or rendered unproductive, the most fertile territories, seemingly unable to turn them to account, the country and people to which you belong compelled the ocean to retire from a barren, unprofitable, and untillable soil, which they converted into a garden; and if ever the great problem of rendering the whole earth habitable for man be solved, I may venture to predict—with all due respect for other nations and other races—that the solution must come from Holland. As it would be presumptuous in me—a humble individual—directly to address a nation, I have ventured to do so indirectly through you. Permit me, therefore, to dedicate this little work to you, as the expression of my personal regard and friendship, and of my deep respect for the nation to which you belong.

I am, Sir,

Most respectfully yours,
The Author.

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ERRATUM.

Page 98, line 2 (note), *should read* “Hydrogen is the lightest known substance; its specific gravity is to that of air 732 to 10,000.”

AN INQUIRY

INTO

THE ORIGIN AND INTIMATE NATURE

OF

MALARIA.

INTRODUCTION.

In addition to the wide-spread desolating epidemics which appear from time to time, mysterious in their origin, progress, and cessation or disappearance—such, for example, as the plague of Athens, the plague of London in the time of Charles the Second of happy memory, the Indian or Asiatic cholera of modern times, and the disease called influenza, a frequent visitor to Western Europe during the last half-century—there exist localities unceasingly under the influence of a poison inimical to human life. This poison, since it may be so called, is known to haunt the deltas of large rivers, and seems to be always present there; but it is found also, if we may determine its identity by the identity of its deleterious influence on men, in other and very various localities: sometimes it shows itself—and this most commonly—in marshy and fenny countries, where no large rivers exist, at other times by the banks of fresh-water lakes; now it haunts the forest, and now the open plain, where marsh and fen, swamp and decaying vegetation, seem all but absent. As the inhabitants of such localities are especially afflicted with the fevers called intermittent and remittent, it is the most natural thing in the world to ascribe to the locality itself the origin of these diseases. When, however, we attempt to generalize and assign to the same cause in a more concentrated form those terrible fevers which render

tropical countries the graves of Europeans, great difficulties arise, and numerous objections, which the best of statisticians, not to mention the simply medical observer, have failed to elucidate and remove. Thus physicians are not agreed as to the identity of the poison under all circumstances, or in other words, demonstrative evidence is still wanting to prove that the cause of fever on the western coasts of Africa is identical with that which has so often in the Antilles destroyed England's chosen troops, decimated her fleets, crippled her power, annihilated her army, as at Walcheren, and broken up the health of many a sturdy yeoman by the banks of the Scheldt, of the Thames and its tributaries.

To this poison the term malaria has been applied—a word borrowed from the Italian. This malaria is presumed, whatever it may be, to be the cause (though not exclusively), on evidence almost amounting to a certainty, of the fevers marked by intermissions and remissions; it may also be the cause of the more terrible febrile diseases called the yellow fever, the black vomit, &c., of tropical countries. On this I do not insist. As regards intermitting and remitting febrile affections, we are all but certain that to such localities as I have just alluded to, their origin may be traced, however they may originate elsewhere. A long residence in Holland and Belgium (countries supposed by many to be in an especial manner the hot-bed and active parent of malaria) has enabled me to observe, I trust in an unprejudiced manner, some facts which may have escaped the observation of others. Long resident in that land, on which perished miserably the best equipped army (an army composed of veterans) which ever, perhaps, quitted England for foreign aggression; in that land on which perished the chosen garrisons of the mighty Napoleon; on that spot where they dragged on a miserable existence, or perished in the prime of life; the writer of this essay enjoyed the best of health. Even admitting the full influence of a vigorous constitution, and an innate vitality equal to the neutralization of all malaria, a something must still be ascribed to observation leading him to avoid the hurtful and insalubrious agencies at work around him—agencies ever active, ever seeking to destroy. This information the author has thought might be useful to others, and with this view he submits it to the public.[2]

CHAPTER I. MALARIA—ITS SUPPOSED ORIGIN.

Thus stood the question of malaria towards the close of the last century, and for some years afterwards; its existence in certain localities was never questioned—no one pretended to say that the fens of Lincolnshire and of Cambridgeshire, the lowlands of Essex and Kent, the muddy shores of the Scheldt and the Lower Rhine, the delta through which the rapid Rhone finds its way to the Mediterranean, were healthy countries. No one questioned the presence of malaria there, or its power to inflict the plague of intermittent or remittent fever on most strangers and on not a few natives who happened, unfortunately for themselves, to be susceptible of its influence. The poison gave to the Pontine Marshes a world-wide celebrity.

Again, of the more terrible febrile diseases of tropical climates, it was suspected by many and boldly asserted by most medical men, that to a malaria identical with that of Europe, but more concentrated by high temperature, they owed their origin. Yet no one up to the period I allude to—no physician, at least—had ascribed to neglected drains, ill-conditioned sewers, imperfectly trapped cesspools, overflowing dead-wells, &c., the origin of a malaria much more destructive than the celebrated malaria of fenny or marshy countries, the malaria, if such it really be, equal to the production of that plague, never absent, at times most destructive—the dreadful typhus[3] of Western Europe.

At last one man, a shrewd, intelligent, and influential observer, a man of genius, gave to the whole question a new phasis. Since his day his hypothesis (for we shall presently find that as yet it deserves no better name) has undergone a variety of modifications, as was to be expected, in no way, however, affecting the practical deductions originally drawn from it by its author. A brief history of this curious episode in medicine, honoured by some with the pompous title of “a revolution in sanitary science,” will fitly precede the inquiry on which I am about to enter. Like the small white cloud warning the navigator of the approaching tornado, this hypothesis, from its first appearance as a humble essay in a monthly journal, has repeatedly assumed, by force of circumstances, gigantic dimensions. Of it, as of Rumour, it may be truly said, *Vires acquirit eundo*: it gathers strength from motion. As is usual in England, a machinery has been tacked to it of a character most heterogeneous, but withal so heavy as

already to threaten to surpass endurance—of the truth of which remark no further evidence need be adduced than the modest demand of six millions sterling to depurate or cleanse the Thames of those very materials which, as a first experiment, and by no means an unprofitable one, the Sanitary Board ordered and compelled the inhabitants of London to throw into it. A brief history of this remarkable phasis of sanitary science, as it is called, may prove acceptable to my readers.

CHAPTER II. THEORIES OF MACCULLOCH.

About thirty years ago, as I have already remarked, one of the most distinguished practical geologists of this or any other country directed his attention to a subject of much greater difficulty than the classification of rocks, and their subdivision into primary, secondary, volcanic, and transition. His object was to discover the origin or cause of those fatal diseases which, under the names of fever, dysentery, plague, rheumatism, &c., render the position of man on the globe so precarious, his life at times so brief, valueless to himself or to others, his prospects so gloomy; in brief, by tracing to its origin, if possible, the active agent of such woes to man, to destroy its fatal influence by practical hygienic measures. In a word, Dr. Macculloch hoped, by discovering the cause, to devise the means either of effectually destroying malaria—using the term, however, in a sense at that time peculiar to himself—or so to mitigate its effects as to render it less destructive to mankind.

He, an acute and original observer, statistician, and scientific man, properly so called, did not require to be instructed as to the lamentable results which the premature death of millions causes to the surviving relatives—results so eloquently and so correctly depicted by the illustrious Quetelet in his work on Man.[4] Of all this he was well aware, and a consciousness of such a condition of humanity, and a firm belief in the opinion that the cause lay in some defect in our social system, remediable by human means, led to those inquiries on which the late Dr. Macculloch based his theory of a universal malaria the cause of most diseases—a theory now adopted in its entirety by a large section of the medical faculty, and by the English Government of the present date.

The theory or theories of Macculloch,[5] as expounded by himself, amounted in fact to this—that a poison, which may be called malaria, is generated by vegetable and animal substances whilst undergoing decomposition or putrefaction, and that to the presence of this poison may be traced most of the diseases afflicting civilized man. In a neglected drain or sewer he saw the cause of typhus, of agues, of skin disease, neuralgias, &c.

These views of Macculloch respecting the origin of malaria and its effects on man, were, when first published, and indeed for many years afterwards, looked on with suspicion by the physicians of that day; they were viewed, in truth, as

wildly speculative, and wholly unsupported by facts. This opinion still prevails with many, but they are being rapidly borne down by a host of writers—many, it must not be overlooked, enjoying lucrative official appointments, and who thus have a deep and touching interest in supporting and maintaining the theories of Macculloch. An opportunity will occur in the course of this work of tracing briefly the progress of the mania—for such, to a certain extent, it speedily became—and of assigning the merit or demerit of the movement to those to whom it may be due. Here it is only necessary to allude to it as being in fact the source of all those visionary and Utopian schemes for the entire renovation of the social state of man, alternately advocated or deprecated by a press naturally chiming in with the prevailing public feeling. At times the discussion acquires an almost feverish character—as when, for example, during the present summer, "the river" exhaled an odour more than usually unpleasant; at times it cools down in the presence of a proposal to expend many millions of the public money on some wild, untried scheme, under the superintendence of the very men who deliberately, and despite many warnings, reduced "the river" to its present sad condition—of men who had not the candour or the honesty to admit that, proceeding on the conjectures of Macculloch, they hazarded one of the coarsest experiments ever devised on the health of millions.[6] These were the men whose course of action the Registrar-General endeavoured to palliate, on the plausible ground that, although they poisoned the river, the doing so was much less injurious to the inhabitants of London than to suffer the cesspools to continue any longer buried in the earth, although for the most part hermetically sealed! Thus were they permitted in open day to pollute the surface-drains of the metropolis, converting them into sewers—to render the streets and squares impassable—and finally to convert the river itself into a kind of elongated cesspool! This, says the Registrar-General, is an evil of less magnitude than the permitting the cesspools and dead-wells to remain as they were until gradually and cautiously disposed of by other means.

It were easy to show, were it worth while—1st. How the persons to whom I here allude suffered to be withdrawn from the Thames nearly a half of its natural waters before reaching London; 2nd. How next they converted the healthy surface drains of London and of its environs into odious sewers, ignoring the distinction between drain and sewer, a distinction which the most ignorant of day labourers perfectly understands, and heretofore had uniformly respected; 3rd. How they refused to suffer the suicidal act to proceed gradually and slowly, whereby the river, out of its own natural resources, might and would in time have accomplished its own depuration, but as best suiting their ultimate views,

issued compulsory edicts on the inhabitants of this great city to empty into the river, and almost at once, the accumulated *excreta* of a quarter of a century, such being at least the average age of the contents of the cesspools. Thus was demanded of the river a depurative force at the least twenty times greater than under another system would have been required of it. Lastly, to complete a series of experiments so injurious to the public, but so profitable to individuals, the same party proposes further to deprive the stream of all aid in the purification of its waters, by pouring into the German Ocean the entirety of the water which the natural drainage of London, and the valley in which it stands, contribute to it, together with one-half the waters of the river itself, taken from it above the tide-way for the supply of the capital.

Thus, by a series of manœuvres, transparent enough to those who have carefully watched the movements for the last twenty years, its inhabitants are now called on at their own expense to remedy the clumsy experiments of those who occupy positions they could not fill in any country but England.7

Four-and-twenty centuries ago, Hippocrates, the father of medicine, gave to the world his celebrated treatise, *de aere, aquis et locis* (Περι ὑδατων αερον καὶ τοπων), having for its object an inquiry into the influence of the external world on man's physical structure and moral nature. To trace the origin of disease to these circumstances, does not seem to have fallen within the scope of his argument; accordingly, it can scarcely be said that any author prior to Macculloch ever considered this matter from a philosophical or physiological point of view, a reason for which may be found, I think, in the absence of a minutely accurate chemical analysis of natural and artificial products. No Ehrenberg had taught mankind the wonders of the living microscopic world of life; even the geology of Macculloch was much behind the profound analyses of the present day. Sober thinking men had rejected the bold speculations of Buffon as to the antiquity of life on the globe, and the demonstrations of the immortal Cuvier were as yet but partially admitted; whilst the theories of Lamark, respecting the vast influence of life in the construction of the crust of the globe, had been suffered quietly to fall into abeyance. Life was thought to be but a recent acquisition by the earth; the Silurian and Cambrian systems of fossils were either unknown or misunderstood. These fossils, at present called "the first stages of this grand and long series of former accumulations," must, in the nature of things, yield their claims to others which geology will no doubt soon discover, thus rendering more than probable the theory that life and the globe are coeval.

Placed accidentally in a country usually considered as a focus or centre of that malaria or influence, whatever it may be, which man, correctly, perhaps, esteems as the source and cause of remittent and intermittent fevers, I have thought it might prove a labour of some utility to mankind to test the theoretical opinions to which I have alluded, by an appeal to facts submitted to more refined analyses than were known at the period of their promulgation. Time can only show in how far the views I venture to substitute for those now in vogue fairly represent the truth. A power of nature, invisible and impalpable, harasses mankind, destroys armies,[8] desolates districts and countries, slays adult man at the moment when his native land expects from him a suitable return for all the labour, trouble, and expense bestowed on him: to inquire into the nature of this poison is the object, or at least the main object, of this work. If we would rightly understand its essence and properties, it may be admitted that we ought to study carefully in the first instance its manifestations and effects; now these are tolerably well known. The most difficult part of the inquiry remains, that is, the demonstration of the essential nature of the poison or miasm giving rise to such disastrous results. All modern science leads to the conclusion that malaria, whether it originate in circumstances over which man has no control, despite every hygienic effort, or emanate from a combination of circumstances mainly caused by man himself, or be only effectual when it meets with individuals living in contempt of common sanitary precautions, must, by its material nature, be within the range of philosophical research. To Schonbein, a distinguished chemist now alive, we owe the discovery of ozone. Major Tulloch had already hinted at the doctrine that the cause of the frightful mortality in tropical countries was to be looked for in electrical conditions of the atmosphere, of whose nature we as yet are ignorant.[9] Other discoveries in this direction are sure to follow at no distant period. What so obscure a short time ago as electricity? Now look at its position, at least, as a science of application! Life, it is true, is the mystery of mysteries, equally so in its origin and extinction; yet granting this to be a truth, and foreseeing in it all the difficulties of every inquiry directed to elucidate its essential nature, every reflecting mind must be struck with the remarkable discoveries of modern times, all tending to show the close alliance between the chemical and vital phenomena, an alliance wholly unknown to the most gifted of antiquity. The modern world, right or wrong, looks to chemistry for the solution of many great and important problems, the most elevated of which unquestionably is the discovery of the causes rendering certain wide-spread localities of this earth unfit for the habitation of those at least who may not claim them as their natal soil; of which they are not the aborigines.[10]

CHAPTER III. THE ORIENTAL PLAGUE—QUESTION OF CONTAGION.

A very few years ago it was the general opinion, even of the best informed, that epidemic diseases originate in atmospheric influences over which man has no control. A reservation seems, however, to have been made in respect of the Oriental, or as some term it, the African, plague, a malady the most frightful to which man is liable. Writers of the highest order traced to a damp, hot, and stagnating air, generated from the putrefaction of animal substances, and especially from the swarms of locusts, not less destructive to mankind in their death than in their lives, the fatal disease which depopulated the earth in the time of Justinian and his successors. The disease was reported to have first appeared in the neighbourhood of Pelusium, between the Serbonian bog and the eastern channel of the Nile. Thence tracing a double path it spread to the east, over Syria, Persia, and India, and penetrated to the west, along the coast of Africa, and thence to the continent of Europe. But in order to explain how it spread, it was necessary to invent another theory and add it to the first; the disease once generated, was said to spread by contagion. It is related in "The Decline and Fall of the Roman Empire,"11 that in the spring of the second year (after its first appearance), Constantinople, during three or four months, was visited by the pestilence. It did not reach the capital of the empire at once, but travelled slowly and irregularly, after the manner of modern cholera. In the admirable descriptions of the immortal historian, we can trace all the symptoms of the true Oriental plague, identical in its phenomena and effects with the sufficiently numerous visitations which have since occurred, and with that no doubt which, lately originating at Bengazzi, and spreading to Tripoli, once more threatens the European family of nations. In a damp, hot, stagnating air, observes the historian, who in his account follows Procopius, this African fever is generated from the putrefaction of animal substances, and especially from the swarms of locusts, "not less destructive to mankind in their death than in their lives." But the ferment and putrefaction thus created scarcely accounts for the origin of the disease, and its extension north-wards into the coldest regions of Europe is inexplicable on such a hypothesis, though aided by the modern hypothesis that its propagation is due simply to the neglect of sanitary regulations, a theory now happily extended to all zymotic diseases. Passing over the question as to the contagious nature of plague, typhus, cholera, scarlatina, measles, a question still

undecided, and adhering simply to facts, we are assured by Procopius, the fidelity of whose descriptions the great historian seems disposed to vouch for, that the disease always spread “from the sea coast to the inland country; the most sequestered islands and mountains were successively visited; the places which had escaped the fury of its first passage were alone exposed to the contagion of the ensuing year. The winds might diffuse that subtle venom; but unless the atmosphere be previously disposed for its reception, the plague would soon expire in the cold and temperate climates of the earth. Such was the universal corruption of the air, that the pestilence which burst forth in the fifteenth of Justinian, was not checked or alleviated by any difference of the seasons. In time, its first malignity was abated and dispersed; the disease alternately languished and revived; but it was not till the end of a calamitous period of fifty-two years that mankind recovered their health, or the air resumed its pure and salubrious quality. No facts have been preserved to sustain an account, or even a conjecture, of the numbers that perished in this extraordinary mortality. I only find that during three months, five, and at length ten thousand persons died each day in Constantinople; that many cities of the East were left vacant, and that in several districts of Italy the harvest and the vintage withered on the ground. The triple scourge of war, pestilence, and famine afflicted the subjects of Justinian; and his reign is disgraced by a visible decrease of the human species, which has never been repaired, in some of the fairest countries of the globe.”

The plague of the time of Justinian is known to us only through the medium of the Greek and Roman writers. We know nothing as to how it affected the remote East, or whether that portion of the earth escaped. No record exists to prove or disprove the passage across the Atlantic, in ancient times, of plagues and pestilences, such as we know now overleap with ease that seemingly impassable barrier. The history of cholera in its progress from the East, though drawn up by skilful official writers, tells us as little of its real nature as Procopius did of the plague. It resembles in some respects the history of ancient Egypt, each discovery merely adding another enigma to the already existing and unexplained. Its propagation by contagion is still denied by the first of medical authorities, and yet it must be admitted that it pursues in a mysterious manner the paths of commerce, as if by the abuse of trade, plagues, which would otherwise become extinct in the land of their origin, are diffused over the continents of the world.12

The propagation of the plague by contagion was, as we have already seen, distinctly denied by Procopius, and in this opinion he seems, as in modern times,

to have been backed by a majority of the people. The immortal historian of “The Decline and Fall” did not partake of Procopius’ doubts. “Contagion,” he remarks, “is the inseparable symptom of the plague, which, by mutual respiration, is transfused from the infected persons to the lungs and stomach of those who approach them. While the philosophers believe and tremble, it is singular that the existence of a real danger should have been denied by a people most prone to vain and imaginary terrors. Yet the fellow-citizens of Procopius were satisfied, by some short and partial experience, that the infection could not be gained by the closest conversation; and this persuasion might support the assiduity of friends or physicians in the care of the sick, whom inhuman prudence would have condemned to solitude and despair. But the fatal security, like the predestination of the Turks, must have aided the progress of the contagion; and those salutary precautions to which Europe is indebted for her safety, were unknown to the government of Justinian. No restraints were imposed on the free and frequent intercourse of the Roman provinces. From Persia to France the nations were mingled and infected by wars and emigration, and the pestilential odour which lurks for years in a bale of cotton was imported by the abuse of trade into the most distant regions.”13

Thus has been bandied about from the earliest times to the present day, the great question of the origin of the pestilential diseases, and their contagious properties when once produced. The question still remains unsettled, nor has the advent of the cholera in modern times contributed in the slightest degree to bring the disputation to a demonstrative issue.

Are they of terrestrial or atmospheric origin properly, or do both contribute their share towards the production of pestilences? How originated the cholera, and how does it spread? These questions may still be asked, and when asked must remain unanswered. The share ascribed to man in the production and propagation of this and similar diseases is mainly the object of this inquiry, and to that I shall adhere as much as possible.

Men, ever anxious to discover the causes of events, ascribed the origin of the plague in the reign of Justinian to the putrefaction of locusts; but the same event may and has happened without being productive of similar results—without, indeed, causing any disease whatever, as if the poison, though present, were ineffectual unless aided by other circumstances at present unknown to man. Those who have seen cholera only as it prevails on the rotten banks of the Ganges, ascribe its origin to heat and putrefaction, its extension to the habits of a

densely-congregated people. They forget, or choose not to remember, that it raged in the depth of winter in the cold regions of Russia and of Scotland, in thinly-populated villages, in hamlets, and insulated cottages, scattered over the elevated yet cultivated estates of noble and wealthy proprietors.14 Those who have studied the phenomena of typhus only in the horrid slums of Glasgow, in the wynds and closes of cold and bleak Edinburgh—from which it is never absent, occasionally raging with something like the virulence of a plague—ascribe the origin and extension of the disease to cold and hunger, to a deficiency of animal food, and to a contempt for all sanitary arrangements; but they do not choose to remember that a few years ago typhus in its worst form appeared in the south-eastern angle of England, spreading thence through the midland counties, deeply affecting the population of hamlets and villages the salubrity of whose site was unquestioned. And if negative evidence be held sufficient to refute Procopius' theory of the origin of the true plague, we have but to look into the pages of a modern traveller, whose official position naturally adds to the value of his testimony. Mr. Barrow, in describing a visitation of locusts to the Cape of Good Hope, makes the following curious remark:—"Their last departure was rather singular. All the full-grown insects were driven into the sea by a tempestuous north-west wind, and were afterwards cast upon the beach, where it is said they formed a bank of three or four feet high, which extended from the mouth of the Bosjesman river to that of the Becca, a distance of nearly fifty English miles; and it is asserted that when this mass became putrid, and the wind was at south-east, the stench was sensibly felt in several parts of the Sneuwberg." The distance over which the stench was felt must have been at least a hundred miles, the range of the Sneuwbergen being at about this distance from the coast.

It is hardly necessary for me to observe, that no disease followed the destruction and putrefaction of these locusts. The colony of South Africa still continues free from plague and cholera, and many other diseases afflicting the most favoured of European lands; consumption, scrofula, and fever are all but unknown. I am not aware that the inhabitants are in any way remarkable for their sanitary arrangements, whilst of the Hottentots it may with truth be said, that they are at once the healthiest and dirtiest people in the world.

Thus, after the lapse of many centuries, the great questions debated in the time of Justinian—may we not rather say in the days of Thucydides?—surge up again whenever a new plague appears on the earth. The professors of "the conjectural art," anxious to vindicate their claim to activity, and to share in the laudations

bestowed on the superior intelligence of the present day, offer at present a highly consolatory view, not only as to the origin of these diseases, but as to their speedy suppression. They argue that, but for the neglect of hygienic measures, such influences or poisons would either not arise, or would pass on their course, leaving the nations unscathed. In the meantime, it is prudent to recall to the recollection of those who arrive rashly at conclusions such as these—who theorize on narrow local ground—who are sanguine enough to look forward to the speedy extinction of all zymotic diseases, that pestilential and destructive epidemics are not confined to man; that, under the form of murrains, they destroy the beasts of the field. In the murrain of 1747, it is stated on authority that 30,000 cattle died in Cheshire in the course of half a year. The marsh districts suffered most; and it has even been conjectured that such epizootic diseases usually originate amidst swamps and malarious districts; but of this we have no proofs. Even the harvests to which man looks for sustenance are not spared—nor the vine; the life-destroying principle, attacking these lower forms of life, cannot well be traced to the neglect of hygienic measures on the part of man, or of the animals or plants themselves; and yet in the midst of these bogs and marshes which undeniably give origin to some forms of fever, the buffalo, the ox, the camel, the elephant, and the wild of all species, live and thrive. Thus the question of the origin of disease is complicated *ab origine*; the origin of typhus—that scourge and pest of the nations inhabiting the temperate regions, more especially of Western Europe, and of the British Isles in particular—is absolutely unknown. To affect to trace it to a foul drain, an uncleansed sewer, an untrapped cesspool, a laystall, a collection of neglected rubbish, is clearly against the evidence and the daily experience of thousands; but all are agreed that in certain fenny and marshy countries fevers prevail—intermittent in temperate, remittent in ardent climes nearer the tropic; whilst within the tropics the life of the European stranger can scarcely be valued at a week’s purchase.[15] To this destructive influence, most commonly connected with a marshy soil, the Italian first gave the name of malaria—a useful appellation, universally accepted as implying no theory; and had such fevers been found only in such localities, the inference must have followed, that a something, open to the chemist to discover, emanating or produced by these marshes, was solely and distinctly the cause of all such fevers. But now a more careful and extended inquiry shows that such fevers are not confined to those districts, but infest even the hay-field, are not unfrequent in or near woods growing on soils where marshes have ever been unknown; whilst as regards the more ardent remittents of Eastern countries, the statistics of Major Tulloch have all but destroyed the theory which would trace to marshes exclusively the fevers which in such countries set all medical

treatment and all human precautions at defiance.[16]

This uncertainty of life from the effects of malaria must ever, I think, remain whilst the true nature of the poison is unknown; and it is with a view to discover, if possible, the circumstances under which it originates, that I undertook this difficult inquiry. Long resident in a country supposed to be an ague-producing land, I watched with much interest the social condition of a sagacious, prudent, and industrious race of men, who could thus, at one and the same time, preserve their liberty and life from the hostile assaults of furious, implacable tyrants from without, and of an insidious, invisible enemy within, walking stealthily around the habitations of men, poisoning the air of his house, his fields, and gardens. It was in Holland that a French general, writing to the great Napoleon, and complaining of the destruction of the garrisons by fever, received from him the only reply which at the time the necessities of the mighty conqueror permitted him to give—"*L'homme meurt partout*." "Man dies everywhere," was the only answer, if answer it could be called, to a kind-hearted commander, more touched by the calamity around him than by the exigencies of the State.

But how was it that whilst French and English soldiers perished so unaccountably in the prime of life, the inhabitants of these countries lived seemingly unaware of the pestilence walking around and amongst them? This problem may, I think, be solved; and as not foreign to the matter in hand, I may be permitted to glance at the character, position, and social condition of a race and a nation so distinct from all other branches of the great European family. My remarks will bear mainly on the influence they exercise over the portion of the earth they inhabit, and on the modifications which man's industry, guided by prudence and science, may imprint on "the earth, the air, and water" of the territory which, under the circumstances I now describe, may especially be called their own.

CHAPTER IV. HOLLAND AND BELGIUM, THE LAND OF MARSHES AND OF FEVER, RECLAIMED AND RENDERED SALUBRIOUS BY THE ENERGIES OF A FREE PEOPLE.

Necessity is the mother of invention. “Quis psittacum loqui docuit? Venter: Magister artium.”17 A constant struggle with Nature for existence taught the Hollander and Brabanter a practical philosophy in respect of the management of river mouths, tidal rivers, low levels, freshwater and seawater floods, unmatched by any other nation. It required the unceasing vigilance of the most experienced scientific men to combat the adverse circumstances under which their country was placed. An error of calculation laid waste a province; a breach in a sea-wall let in upon the land not only the ocean, but famine, followed by its sure accompaniment—fever, and a wide-spread mortality.

In this land there was no room for experimental jobbery. To have placed a linendraper at the head of the great hydraulic works on which depended the salubrity and prosperity of Amsterdam or Rotterdam would have roused the indignation of the country, and brought the matter to a speedy issue. But it was not until the rise of the Dutch Republic that there sprung up, as a natural result, a school of philosophy—of natural philosophy, and of the sciences of observation and application—hitherto unmatched, a parallel to which can only be found in the era immediately preceding Alexander the Great. Freedom of thought and action produced Muschenbroek and Leuwenhoek, De Ruyter and Van Tromp: then flourished the Elzevir press, and Scaliger was invited by the traders of Holland to pass his days in peace and plenty with them, that his presence amongst them might throw a lustre on their country. In this land flourished Camper and Boerhaave; Albinus and Ruisch taught anatomy; Swammerdam discovered the globules of the blood. In the meantime Tasman and Van Diemen explored the ocean, immortalizing their names and their country by the grandeur of their geographical discoveries. The views of the traders of this the most celebrated of all republics, were universal, and included mankind: with them originated sound political economy. The civilization, peculiarly human, which overcomes all natural obstacles, reached its height in this free land; security of life and property, equality before the law, a contempt for all sinister hereditary influences, a respect for the natural rights of man, and an appreciation of man’s

innate worth, uninfluenced by all extrinsic circumstances, characterized in the Netherlands a period standing out in bold relief, and in striking contrast with the history of all other European nations.[18] In this forward movement Haarlem was conspicuous, proofs of which may be found in the Transactions of the society established in that city. About 1771 there was offered a prize for an essay on the Waters of Holland, as to the existence of any matters injurious to man or beast, and to describe such, if existing. An unsuccessful candidate for the prize (M. Vander Wild) advanced in his essay this remarkable principle—that the sap of plants consists of living beings, in a liquid element.[19]

As the nation was free to think and to express their thoughts, nothing practical or useful escaped them: the question as to the influence of the drainage of lakes on the health of the inhabitants was ably discussed during the last century, more especially as to the result of draining the lowlands of Biensten, de Wonner, &c. M. Ungo Waard and others describe the sickness which took place on the drainage of Bleewyksthe. In Haarlem, in 1779, the deaths exceeded those of the previous year by 396; in Amsterdam, by 1727; in Groningen, by 752. The previous summer had been hot and dry, offering another proof that the vegetable humus thus exposed to the air, fermenting and rotting, was the cause of the sickness and increased mortality. In this land there was no room—no margin, to use a commercial phrase—for experiments on the pockets and the health of its citizens; they were citizens, not subjects—far-seeing men, who calculated everything *d'avance*. And now the draining of the lake of Haarlem shows that the race has lost little of its ancient spirit of enterprise and industry, of that applicative invention to the wants of civilized man which gives to Holland and to her colonies an aspect to which no other country bears any resemblance. The poisoning of rivers and streams by any combination of adventurers could never happen there, and the scenes we have witnessed lately in England would be wholly unintelligible in Holland. It is here that vast morasses, seemingly valueless, are being converted into fertile meadows, by processes of which the natives of other countries have not the slightest knowledge. In this land it is the law that, before any one be permitted to convert a peat bog into a lake by the abstraction of the peat, security is demanded of him as to his means to drain the lake about to be formed, to embank the excavation, and to convert it into a healthy fertile meadow; in England, on the contrary, such cautious procedure is held in the most sovereign contempt, as wholly unworthy that fine chivalrous character for pluck, daring, and exciting enterprise and speculation which marks the free-born Briton.

“Break up the cesspools,” shout the interested, “the receptacles of the filth of millions for a quarter of a century, and pour them at once into the Thames.” “It will poison the river and the adjoining country for a lengthened period,” suggests the prudent observer of passing events. “Persevere,” exclaims the go-ahead party; “have we not proofs in Macculloch that nearly all known diseases arise from the cesspools? Leave the river to take care of itself.” What, in the mean time, is the course of action of the Mayor and Corporation of the richest city in the world? Fully occupied with the distribution of their revenues, they abandon the river and interests of a vast metropolis to a host of talented and needy adventurers, whose name is legion. The people in Holland and Belgium think that the refuse and excreta of the inhabitants of towns, villages, and single houses cannot be too soon or too effectually buried under or incorporated with the soil; we, in this country, act evidently from a belief that this refuse, the product of civilization, cannot be too extensively spread abroad in the open air, and accordingly a formidable and well-paid staff of more than 2000 persons is organized to carry out the delusion to its conclusion. Luton, Birmingham, and London, afford hints as to what these delusions may one day end in: that they will proceed in their course, I doubt not, for, like Macbeth, they are so far involved, that it were safer to proceed than to back out from their position. This could only have happened in the land where the greatest of all railways does not pay the proprietors one shilling of interest on the enormous capital expended in its construction.

Located by the mouths of the Rhine and Scheld, the ancient Batavians must early have commenced their struggle with nature. We have no information from early history of how that struggle began; but one thing is certain—it was of great antiquity, for in the Morini—the last of men—Cæsar encountered no fever-stricken, wasted, dejected people: they must already have discovered the existence of that hidden enemy, malaria, and taken measures for at least a mitigation of the evil.[20]

CHAPTER V. ON THE PRESUMED SOURCES OF MALARIA.

§ 1. For all practical purposes, the fevers termed intermittent and remittent may be held to have their origin in one cause. Thus, whether on the marshy coasts of Essex and Kent, or the more dreadful banks of the Gambia and Niger, it is not improbable that the fever so destructive to European life is of one character—mild in Essex; fatal in Sierra Leone. But the fact is not to be overlooked, that when fever assumes an intermittent character, however it may conduce to the inefficiency of the population, it does not greatly swell the bills of mortality; on the other hand, the remittent form of fever constitutes that grand and hitherto insurmountable obstacle which Nature seems to have placed to the extension of the white man over the earth, excluding him, seemingly for ever, from the tropical regions of the world.

A favourite theory with medical men was, that the evil influence which causes fever, whether in Essex or on the Gambia, by the Scheld or the Niger, was a certain miasma produced by marshes more or less remote from human abodes; sometimes it was maintained that to produce the miasma these marshes must be in a great measure dried up, or in the process of being so; at other times an opposite opinion was held. These hypotheses were refuted, or at least much shaken, by Major Tulloch, in his invaluable “Statistical Report on the Sickness, Mortality, and Invaliding among Troops on the Western Coast of Africa” (p. 26). “So long as the fever continued to make its appearance during the rainy season, excessive moisture was deemed one of the principal causes, but that theory has been abandoned since it has, on three or four occasions, appeared and raged with equal violence in the middle of the dry season. If we attempt to connect it with temperature, the range of the thermometer offers equally contradictory results, the disease having originated and prevailed nearly as often when that was at the minimum as when at the maximum. Variations in atmospheric pressure afford no clue whatever to the solution of the difficulty, for here, as in all tropical climates, the fluctuations of the barometer are exceedingly slight. No definite connexion has ever been traced between the prevalence of any particular wind and the outbreak of the disease; the breeze blows over the same district in the healthy as in the unhealthy season. Besides, it seems entirely to negative the supposition that any of these can be more, perhaps, than mere accessories, when we find, from 1830 to 1836, the colony of Sierra Leone remarkably free from fever,

without any perceptible change in these respects. It does not appear that the composition of the atmosphere during the prevalence of yellow fever in this command has ever been examined, to ascertain if it differed from what has usually been observed at periods comparatively healthy; but this test has been applied without any satisfactory result in other countries. Unless some light, therefore, can be thrown on the subject by a careful examination of the electrical state of the atmosphere at such periods, there seems little hope of the origin of this disease being ever distinctly traced to any appreciable agency—a circumstance which, except as regards the interests of science, is perhaps of less importance, since where the cause is so exceedingly subtle it would, even if discovered, be in all probability beyond human control."[21]

In corroboration of the same views, amounting in fact to a rejection of the favourite hypothesis of the professors of the healing art—namely, that this fever originated in the miasma of marshes near the station, this careful and honest observer, whose merits as such have subsequently been fully tested in the celebrated Crimean inquiry, makes this further remark:—"The hypothesis that this fever originates from the miasma of marshes in the immediate vicinity of the station, as elsewhere it has been supposed to do, is directly opposed to the fact of the Isles de Loss, Acera, and the peninsula of Sierra Leone itself, being so subject to it, though all are in a certain degree remote from the operation of any such agency. If it be referred to similar exhalations wafted to the distance of several miles, how is its prevalence to be accounted for at Fernando Po, a mountainous region, and bordering on a mainland still more so, and where, so far as can be ascertained, no such agency is in operation? Instances of disease having raged with the same violence on the rocky Isles de Loss and the sandy wastes of Senegal, as in those parts of the coasts where vegetation is most dense, preclude the likelihood of it originating in a superabundance of that agency. In every description of situation along the coast has this scourge of Europeans been found to prevail. The low, swampy Gambia, the barren Isles de Loss, the beautifully-diversified features of Sierra Leone, the open and park-like territory around Acera, the lone, jungle-covered hills of Cape Coast Castle, and the rugged, mountainous island of Fernando Po, however different in aspect, have all exhibited the same remarkable uniformity in giving birth to the disease."

It may, indeed, be objected that the fevers of Western Africa differ essentially from those traceable to the deltas of rivers, and to the lowlands alternately inundated and exposed to a high temperature, of more temperate climates; but I see no good reason in favour of such an opinion. The tables of sickness and mortality distinctly state that the fevers were intermittents and remittents, but

mortality distinctly state that the fevers were intermittents and remittents, but mainly remittents, and that continued or ardent fever was scarcely present; whilst in Canada precisely the reverse is the case, intermittents prevailing to a great extent, remittents being comparatively rare. It would seem, however, that whether or not these fevers spring from a common cause, the temperature of the locality greatly influences the character of the disease.

It is impossible to deny the influence humidity has in engendering malarious tendencies, but it is not necessary that the humidity be to any great extent. Water is essential to life, it is essential also to the production of fermentation, of putrefaction; the absolute desert, as I have already remarked, is always healthy; so is the surface of the great ocean, which although it abounds with life, never putrefies, never exhales unpleasant odours. Countries, like some districts of Southern Africa and of Australia, where it seldom rains, are the healthiest countries in the world; there fevers of all types are nearly unknown, and the sufferers from such coming from unhealthy climates, recover speedily from the sad condition to which a residence in a tropical country and frequent attacks of fever may have reduced them. The Royal African Regiment, composed mainly of deserters, left the west coast of Africa for the Cape of Good Hope in 1817; many of them were so reduced in health as to be obviously unfit for service in any country where fevers of an intermittent or remittent character prevailed. Now, a residence on the frontiers of the colony of the Cape not only cured these fevers, but seems also to have been equal to the removal of those sequelæ of fever and dysentery which haunt those who have greatly suffered from them, bringing them in the end to an untimely grave. Nothing of the kind occurred in this remarkable country; all, or nearly all, recovered, and the mortality and sickness of this shattered corps, removed from Sierra Leone and the Gambia to the frontier districts of the Cape of Good Hope, fell considerably below what it is amongst the same class in Britain. These facts merit the attention of all interested in the welfare of the army of Britain, an army exposed more than any other to the effects of climate in all regions of the world.22

§ 2. The statistics I have just referred to may seem to some to shake all modern theories of malaria that have ever yet been offered to the public. I admit this to be the case; but I trust to be able to show that in the remains of animal and vegetable life, elements collected in the greatest abundance by the banks of rivers and lakes in marshy countries, near shores alternately exposed and covered by the tide, and especially in tidal rivers, but not exclusively in such localities, we have the source of that poison whose terrible effects on human life

need not be enumerated here.

The result of Major Tulloch's report in regard to the relative prevalence at different stations in British America of remittent and intermittent fevers, shows in a still stronger light the difficulty of establishing any uniform connexion between the presence of marshy ground and the existence of these febrile diseases, to which the exhalations from it are supposed to give rise; but they do not refute the view I take,[23] which is based on the researches of the profoundest chemists. As it was formerly shown that in some of the Ionian Islands, totally destitute of marsh and comparatively barren of vegetation, more remittent and intermittent fevers have been under treatment among the troops, than in others where these alleged sources of disease existed in the greatest abundance; so in the present Report we find it established, that yellow fever of the most aggravated form has repeatedly made its appearance in Ireland Island in the Bermudas, a rocky barren spot only a few hundred yards in breadth, "containing no marsh, and with little or no vegetation except a few cedar trees."

"Conversely, again, we find that these diseases prevail to a remarkable extent along the banks of the lakes and the margin of the streams in Upper Canada, while they are comparatively rare in similar situations in the Lower Province; that among the troops at Fredericton, living on the marshy banks of a river, surrounded by a dense vegetation, scarcely a case of them is ever known; and that a similar exemption is enjoyed even by those at Annapolis and Windsor in Nova Scotia, though quartered at the *embouchure* of rivers daily subject to extensive inundations, and of which the banks, for the distance of several miles, exhibit that combination of mud, marsh, and decayed vegetation which is generally supposed a most prolific source of such diseases.

"When in subsequent reports we come to investigate the operation of these diseases on the west coast of Africa and other colonies, we shall be able to adduce still more satisfactory evidence on this subject; in the meantime we have felt it our duty to place the preceding facts in a prominent point of view, not for the purpose of establishing any particular theory, but to show how inadequate in many instances is the supposed influence of emanations from a marshy soil to account for the origin of these diseases. All the evidence obtained seems only to warrant the inference that a morbific agency of some kind is occasionally present in the atmosphere, which, under certain circumstances, gives rise to fevers of the remittent and intermittent type; and that though the vicinity of marshy and swampy ground appears to favour the development of that agency, it does not necessarily prevail in such localities, nor are they by any means essential either

necessarily prevail in such localities, nor are they by any means essential either to its existence or operation.

“Notwithstanding the doubt in which this branch of the investigation is still involved, we may venture, from the facts adduced in all the reports hitherto submitted, also to draw the conclusion, that when this morbific agency manifests itself in the epidemic form, its influence is frequently confined to so limited a space as to afford a fair prospect of securing the troops from its ravages by removing to a short distance from the locality where it originated. The history of the epidemic fevers at Gibraltar furnishes several remarkable instances of this kind, and we have also shown that, both in the West Indies and Ionian Islands, one station has frequently suffered to a great extent from yellow fever, while others within the distance of a few miles have been entirely exempt.

“In the epidemic cholera at Montreal and Halifax, which seems to have been in this respect somewhat analogous in its operation, we have also had occasion to remark the sudden cessation of the disease immediately on the removal of the troops to a short distance.”[24]

The discordance prevailing between observers, equally honest, equally intelligent, arises, no doubt, from this, that all the elements of the problem to be solved are not yet discovered; nor could this be expected until a refined chemistry had more fully developed the relation between chemical and physiological phenomena. The very essence of the affinities between the soil and vegetable and animal life was a complete mystery until lately, whilst the relations of the superambient atmosphere to the organic remains of what had ceased to live, were wholly misunderstood. The cause of the potato blight, which produced a famine in Ireland, is still a mystery; so also is that of the vine. A disease very fatal to horses, called Paard-sick, from its only attacking the horse, is endemic in some districts of the Cape; that is, in the healthiest country in the world. The nature of the Paard-sick has never been discovered. It spares the *wilde* of the horse genus—the quagga, zebra, &c.—but is fatal to the domestic breed. Man’s interference, then, proves at times fatal to his protegée. It is everywhere the same, unless his interference be guided by all the lights which the highest reasoning powers, the shrewdest observation, and oft-repeated experience can afford. The two Canadas are in an especial manner the land of rivers, lakes, marshy forests, swampy meadows, and a soil into which the plough never penetrated until the white man appeared. As a natural result, it might be conjectured and presumed that intermittents and remittents, under at least certain of their forms, would be equally frequent and universally diffused. Statistics

prove it to be directly the reverse, Upper Canada being to Lower Canada, in respect of these fevers, as 178 intermittents is to 26 remittents; whilst even of these 26 it is affirmed that the greater number of them came from the Upper Province. To show that I do not exaggerate this singular fact, I quote the remarkable statistics of Major Tulloch.

“Taking the results of these ten years as the basis of our deductions, then, the prevalence of intermittent fevers in Upper compared with Lower Canada is as 178 to 26. It is necessary, however, to keep in view that all the admissions (amounting only to 26) from intermittent fever in Lower Canada did not originate there, by far the greater proportion of them having occurred among soldiers who came from the Upper Province while labouring under that disease, or who had acquired a predisposition to it during a previous residence there. Indeed, except at Isle aux Naix and the other small stations along the banks of the Richelieu, fevers of the intermittent type are rarely indigenous in Lower Canada; at Quebec they are said to be unknown, and at Montreal nearly so.

“In Upper Canada these diseases prevail most among the troops stationed along the course of the great lakes from Kingston to Amherstberg, they are almost unknown at Penetanguishene and By Town. The settlers who reside even at the distance of a few miles inland rarely suffer from them; yet the districts enjoying this exemption are in many parts covered with lakes, intersected by streams, and abound in marshy ground, decayed vegetation, and all the other agencies to which the origin of this type of fever is generally attributed. A reference to the report on Nova Scotia and New Brunswick will also show that though the same agencies exist to a similar extent at some of the stations in that command, intermittent fevers are almost unknown.

“These diseases, too, are said to be comparatively rare wherever the surface is covered with dense forests, even though the ground is wet and marshy. The vicinity of lands recently cleared is most subject to them, particularly meadows or open patches of the forest, which, though denuded of trees, have not been brought under cultivation. It would appear, too, that their prevalence is diminishing with the progress of agricultural improvement; for it will be observed, on reference to the Abstract of Diseases, No. III. of Appendix, that since 1831—a period during which this province has been rapidly advancing in wealth and population, and many important changes have taken place in the vicinity and stations occupied by the troops—intermittents have become comparatively rare, the proportion attacked having been scarcely one-tenth part

so high as the average previous to that period. Intermittents most frequently occur from July to September, when a high temperature prevails; but they are also to be met with, though more rarely, in spring, when that agency could only operate in a trifling degree to induce them. Though a source of inefficiency among the troops, they add but little to the mortality, as not one case in a thousand proves fatal. A person who has been once attacked is exceedingly apt to suffer from them again; but this susceptibility is easily removed by change of residence to the northern parts of the province, or to Lower Canada.

“In some years, fever also manifests itself along the borders of the lakes in the remittent form, but not of so fatal a character as in the West Indies or the Mediterranean; for only one case in sixteen is found to have proved fatal among the troops.

“The febrile diseases of Upper Canada are by no means uniform in their prevalence. Even in years when the degree of temperature, fall of rain, or extent of vegetation have been much the same, the proportion of cases, particularly of intermittents, is very different. A general impression exists, that their prevalence is in some measure dependent on the height of the waters in Lake Ontario, which attain their maximum in June or July. If, from the quantity of snow or moisture in the course of the year, this is found to be greater than usual, febrile diseases are expected to abound, and the reverse if the maximum has been under the average. As Lake Ontario is the reservoir into which all the waters of Upper Canada are drained off before finding their way to the ocean, this theory, if accurately substantiated, would tend to show how far the origin of these diseases depended on moisture, and we therefore instituted the following comparison between the height of the waters in the lake, as measured at Kingston for a series of years, and the prevalence of fever in Upper Canada during the same period:

	1818.	1819.	1820.	1821.	1822.	1823.	1824.	1825.	1826.	1827.
Average height of lake in Kingston Harbour in each year	ft. in. 14 9	ft. in. 13 3	ft. in. 12 3	ft. in. 11 11	ft. in. 12 1	ft. in. 13 5	ft. in. 13 11	ft. in. 12 5	ft. in. 12 10	ft. in. 14 3
Cases of										

Cases of intermittent fever in Upper Canada	110	319	509	348	222	143	171	135	111	220
Cases of other fevers	109	54	150	152	132	69	168	190	155	185

“Here we find that, though in the last of these years the maximum height of water in the lake happened to correspond with the greatest prevalence of fever, the latter can by no means be looked upon as a consequence of, or in any way connected with, the former; since in 1818, when the water rose to within a few inches of the same level, there was less fever than in any of the years under observation; whereas in 1820 and 1821, when the waters of the lake appear to have been at the minimum, there was more than in any of the years prior to 1828.

“This supposition seems to have originated in the circumstance of fevers being generally most prevalent from June to October, which happens to correspond with the period when the waters of the lake are at the greatest height; but the wide sphere over which these statistical investigations now extend, has enabled us to show that febrile diseases always prevail most at that season of the year, even in countries where no such cause is in operation to produce them; consequently, the rise of the waters in the lakes can no more be regarded as the cause of fever in America, than the cessation of the trade winds about the same period can be deemed a satisfactory reason for the appearance of that disease in the West Indies. Both are merely coincidences which, by those who have not a sufficiently extensive field of observation, are apt to be mistaken for causes.”

There arises out of all such inquiries one obvious deduction—viz., that the essential nature of malaria is altogether unknown; and that unless we choose to remain contented with such vague hypotheses as those of Macculloch, now adopted by the Medical Board of Health of Great Britain,[25] other inquiries must be entered on. The assertion is as easily made as its refutation is difficult, that typhus fever is caused by a neglected drain or ditch; that scarlet fever, small-pox, and cholera have for their origin the same cause; that if they do not immediately produce the poison, they predispose the human frame for its reception; and that as a necessary result, all such diseases, and deaths resulting therefrom, and from

zymotic forms of disease generally, are preventible by human agency. Let us leave these Utopian views to the clever pens skilled in the art of making that seem new which is not new, and that seem true which is not true, and patiently inquire into some of the many difficulties besetting all investigations into Nature’s processes, and man’s interpretation of them.[26]

CHAPTER VI. THE LIVING WORLD—ITS EXTENT AS REVEALED BY THE MICROSCOPE—HOW ITS REMAINS ARE DISPOSED OF WHEN LIFE HAS CEASED.

§ 1. It has been often remarked, and with great truth, that the world abounds with life. In the remains of that which had once lived, which was at one period organic, the illustrious Cuvier and the great school to which he belonged saw the materials of life, the food, in fact, of that which exists; he held that between the inorganic and organic worlds there was an impassable gulf, or in other words, an inconvertibility or a metamorphosis, call it by what name you will. This plausible theory, with many others, is now controverted by modern chemists, who boldly assert that no organic atoms or molecules, as such, can serve as food for a plant or an animal. But be this as it may—for chemists admit that the incombustible constituents or the salts of the blood, so essential to the nourishment or support of animal life, must have passed through organic bodies27—one thing is certain, that the extent of life on the globe can scarcely be imagined. For first, as regards the vegetable kingdom, do we not observe how, as spring and summer advance, the organic beings which during winter had lain dormant at the bottom, or deeply entombed in the waters (I speak not of those to be seen at all times on the surface of the earth), rise to the surface, bringing with them countless myriads of the ova of aquatic animals and of those which haunt the surface of the water? Amongst these stand pre-eminent the infusoria or zoophytes; with these the atmosphere also becomes loaded. They form, in fact, the substratum of all animal life, constituting the food not only of animals somewhat larger than themselves, but of many much larger, as the various species of the cyprinus. Many valuable gregarious fishes, as the herring, char, and the finer species of trout, live on entomostraca; they in their turn become the food of larger and more voracious fishes. Even the whale lives on food a portion of which is almost microscopic. Now, withdraw the water by which all this life subsists, and putrescence, or fermentation and decay, must be the result upon a mass of life of which the amount may be faintly conjectured by the fact that 4,100,000,000 millions of infusoria may be found in a square inch. These insects, when dead, are found in strata extending to some acres, and many of the fossils thus discovered belong to species of genera now alive. The

principles of life were at least as active in what we call the old world (though in reality the young world), as in the present; the researches of Ehrenberg, repeated by many others, have placed these opinions beyond dispute.

Now, it is by no means improbable—nay, it is almost certain—that many species of these infusoria reside in the vapour of the atmosphere.

The Austrian physicians came to the conclusion that the Asiatic cholera was of local or terrestrial origin; the facts mentioned above confirm this view to a certain extent, by disproving the general epidemic laws supposed to regulate the progress of cholera and of fever (in which cholera usually terminates), and by showing that the disease sought out, as it were, the inhabitants of certain districts favourable for the production of the deleterious influences I am now about to consider. When the epidemical influence was superadded to these, the disease appeared; its independence of changes in temperature may have been owing to other circumstances not yet investigated. Connected with this evolution of vegetable life in spring and summer, and with its effects on man, is what is called the blooming of plants. The presence of stagnant waters and of foul ditches may be discovered even at a distance by the odour of gases, especially of the sulphuretted hydrogen, they emit. Now, oxygen decomposes this gas, and thus it is not so dangerous as represented to live near waters impregnated with it; but should mud or vegetable refuse be left exposed by the drying up of the waters, this gas ascends wherever the decayed matter is renewed or turned over. Venice, Amsterdam, and other great cities similarly situated, are not unhealthy, although their canals abound with mud; but so soon as the traffic ceases or becomes trifling, a mud odour arises, originating in what the French call *epuration* or *floraison d'eau*. In every country where there are ponds, canals, or ditches, this vegetable growth takes place so soon as the temperature of the water reaches 60° Fahr. As the quickening of the plants extends from above downwards, from the leaves and stalk towards the roots, these expand, and the mud becomes loosened; the plants imbibe carbon and give out oxygen, and this circulation contributes to the loosening and to the rising of the mud along with the plant. I have witnessed several square yards of mud raised in this way from the bottom of the waters. It subsides, of course, in due time.

We have seen that the vital force has no influence upon the combination of the simple elements, as such, into chemical compounds. "No element of itself is capable of serving for the nutrition and development of any part of an animal or vegetable organization;" the vital force by its influence merely combines inferior groups of simple atoms into atoms of a higher order.

groups of simple atoms into atoms of a higher order.

How stands it with the decomposition of animal and vegetable bodies when the influence of the vital and conservative power has been withdrawn? Let us attend to what an illustrious chemist has said on this subject:—"Universal experience teaches us, that all organized beings after death suffer a change, in consequence of which their bodies gradually vanish from the surface of the earth. The mightiest tree, after it is cut down, disappears, with the exception, perhaps, of the bark, when exposed to the action of the air for thirty or forty years. Leaves, young twigs, the straw which is added to the soil, juicy fruits, &c., disappear much more quickly. In a still much shorter time animal matters lose their cohesion; they are dissipated in the air, leaving only the mineral elements which they had derived from the soil." "This grand natural process of the dissolution of all compounds formed in living organisms begins immediately after death, when the manifold causes no longer act, under the influence of which they were produced. The compounds formed in the bodies of animals and of plants undergo in the air, with the aid of moisture, a series of changes, the last of which are the conversion of their carbon into carbonic acid, of the hydrogen into water, of their nitrogen into ammonia, of their sulphur into sulphuric acid. Thus their elements resume the form in which they can again serve as food for a new generation of plants and animals. Those elements which had been derived from the atmosphere, take the gaseous form, and return to the air; those which the earth had yielded return to the soil. Death, followed by the dissolution of the dead generation, is the source of life for a new one. The same atom of carbon which is a constituent of a muscular fibre in the heart of a man, assists to propel the blood through his frame, was perhaps a constituent of the heart of one of his ancestors; and any atom of nitrogen in our brain has perhaps been a part of the brain of an Egyptian or of a negro. As the intellect of the men of this generation draws the food required for its development and cultivation from the products of the intellectual activity of former times, so may the constituents or elements of the bodies of a former generation pass into and become part of our own frames." "The proximate cause of the changes which occur in organized bodies after death, is the action of the oxygen of the air on many of their constituents. This action only takes place when water—that is, moisture—is present, and a certain temperature is required for its production."

Let us not, then, be surprised at the seemingly discordant results arrived at, and at the contradictory observations which have been made in the best faith possible, and with every regard to truth in science. The circumstances which

seemed to be identical are merely analogous, but in point of fact are essentially distinct, as proved by the results. Changes inappreciable by human sense and as yet by philosophical instruments, may and no doubt do effect results, to man seemingly contradictory, simply because he comprehends them not. As chemical science makes progress, these differences are being reconciled and understood. Thus, as mere temperature exercises a truly remarkable influence over the nature of the products of fermentation, may it not be the efficient cause of the difference we observe between the malaria of the delta of the Mississippi and that floating near the muddy banks of the Scheldt? The juice of carrots, beet-root, or onions, which is rich in sugar, when allowed to ferment at ordinary temperature yields the same products as grape-sugar, but at a higher temperature the whole decomposition is changed—there is a much less evolution of gas, and no alcohol is formed.

In the fermented liquor there is no longer any sugar, and thus may it be in the great laboratory of nature; the product of the fermentation will assume in one locality a character it does not possess in another. The elements are the same; there is merely a change in temperature.

Are there facts to prove that certain states of transformation or putrefaction in a substance, are likewise propagated to parts or constituents of the living animal body? Such facts exist. On no other principle but that of assimilation can we explain the phenomena of poisoning by the puncture of the living hand in dissecting-rooms, the instrument being impregnated with a fermentescible and putrefactive substance, there undergoing a decomposition. Similar, unquestionably, must be the action of animal poisons, such as that of poisonous substances, whether animal or vegetable, of the poisons giving rise to zymotic diseases, &c.; and such may be the origin of the fevers caused by the unknown principle which must still be connected with the decomposition of organic bodies most frequently found in marshy countries. But before entering more fully on this important matter, I shall first weigh the evidence for and against a theory long fashionable, and which may even now have its supporters—namely, whether fermentation or the revolution of higher or more complex organic vegetable into less complex compounds, be the effect of the vital manifestations of vegetable matters, and whether putrefaction or the same change in animal substances be determined by the development or the presence of animal beings. They who maintain this theory, assume as a natural consequence of the views that the origin of miasmatic or contagious diseases, in so far as they may be referred to the presence of putrefactive processes, must be ascribed to the same

or to similar causes.

§ 2. The refutation of this view by Liebig seems satisfactory, and has not yet been satisfactorily replied to. The subject is one of much interest; the theory has furnished a foundation for some unquestionably entirely fallacious ideas concerning the essence of the vital processes generally, of many pathological conditions, and the causes of certain diseases.

These persons regard fermentation, or the resolution of higher or more complex organic vegetable atoms into less complex compounds, as the effect of the vital manifestations of vegetable matters; and putrefaction, or the same change in animal substances, as being determined by the development or the presence of animal beings. They assume as a natural consequence of this view, that the origin of miasmatic or contagious diseases, in so far as referrible to the presence of putrefactive processes, must be ascribed to the same or similar causes.

The most obvious and important considerations in support of this view of fermentation, are derived from observations made on the alcoholic fermentation, and on the yeast of beer and of wine. The microscopic researches of physiologists and botanists have demonstrated that beer or wine yeast consists of single globules strung together, which possess all the properties of living vegetable cells, and resemble very closely certain of the lower family of plants, such as some fungi and algæ.

In fermenting vegetable juices, we observe, after a few days, small points, which grow from within outwards; and these have a granular nucleus, surrounded by a transparent envelope. The simultaneous appearance of the yeast-cells and of the products of decomposition of the sugar, is the chief argument in support of the opinion that the fermentation of sugar is an effect caused by the vital process, a result of the development, growth, and propagation of these low vegetable structures. But if the development increase, and propagation of these vegetable cells or tissues be the cause of fermentation, then in every case where we observe this effect we must suppose that the causes or conditions—namely, sugar, from which the cell-walls are produced, and gluten, which yields their contents—are both present.

Now, the most remarkable fact among the phenomena of fermentation, and that which must chiefly be kept in view in the explanation of the process, is this, that the ready-formed cells, after being washed, effect the conversion of pure cane-

sugar into grape-sugar, and its resolution into a volume of vapour and alcohol, and that the elements of the sugar are obtained without any loss in these new forms; that consequently, since three pounds of yeast, considered in the dry state, decompose two hundred-weight of sugar, a very powerful action takes place, without any notable consumption of matter for the vital purpose of forming cells. If the property of exciting fermentation depended on the development, propagation, and increase of yeast-cells, these cells would be incapable of causing fermentation in pure solutions of sugar, in which the other conditions necessary for the manifestation of the vital properties, and especially the nitrogenous matters necessary for the production of the contents of the cells, are absent.

Experiment has proved that in this case the yeast-cells cause fermentation, not because they propagate their kind, but in consequence of the decomposition of their nitrogenous contents, which are resolved into ammonia and other products —that is, in consequence of a decomposition which is exactly the opposite of an organic formative process. The yeast, when brought into contact successively with the new portions of sugar, loses by degrees entirely its power of causing fermentation, and at last nothing is left in the liquid but its non-nitrogenous envelopes or cell-walls.28

On the other hand, it may be admitted that fungi and agarics, and all that lives, vegetable and animal, contaminate the air when dead; they absorb oxygen and give out vapours of which some are clearly detrimental to human life. The effect of breathing air so contaminated is in some countries immediate—that is, the incubation of the poison requires only a few days, in others many months. Waters in a state of fermentation or putrefaction seem to poison the plants themselves, for duckweed and other swimming plants die, and the swallow and the marten disappear. On the wide ocean and over the absolute desert, the air is always pure, nothing living is decomposing; but watch the mud coasts, and observe the pestilential effects of sea water when suffered to evaporate, or still more when confined to a locality and suffered to decompose. In the ancient world, as in the modern, nature teemed with life, since a cubic inch of the fossil infusoria, contains 41,000 millions of individuals. The microscopic shell fish called entomostraca were equally abundant.

When the evaporation of sea water is quickened by an elevation of temperature, as in the South of France, noxious and unpleasant odours, injurious to vegetable life, are distinctly perceptible. The putrescence and fermentation caused by heat acting on the remains of life in sea water left to evaporate, as between Rio and

acting on the remains of life in sea water left to evaporate, as between Rio and Cape Frio, in the Brazils, seem to be the cause of, or at least to give terrible effect to, yellow fever.

Vegetable life is equally abundant, and it may be as injurious when decomposing in its effects on human life. Lichens speedily cover the walls of neglected houses, and cause sickness by their decomposition. The spore or sporule, which in flowerless plants performs the office of seeds, floats in the atmosphere, and seems to be the cause of the hay-fever so frequent in fertile lowlands. Nor need we quote the recent drainage of the Lake of Haarlem in proof of the sure results of exposing masses of dead animal and vegetable substances to putrefaction—namely, ague, various fevers, and other ailments indicative of a poison or malaria affecting the general mass of the blood. Of the minuteness of animal life, it is only necessary to remark that we are acquainted with animals possessing teeth and organs of motion, which are wholly invisible to the naked eye. Other animals exist which, when measured, are found to be many thousand times smaller, and which nevertheless possess the same apparatus. Their ova must be many hundreds of times still smaller. It is to this invisible world in all probability, and to its decomposition and putrefaction, or at least to influences arising therefrom, that the essential cause of ague, and other febrile diseases of an intermittent and remittent character may be referred, aggravated, no doubt, by insalubrious atmospheric constitutions of which we know nothing. These from time to time affect and lower human vitality—a fact admitted by all physicians.

Note on the Question of Quarantine. (See Chapter IV.)

The special-pleaders who formed the Council of the late Board of Health argued that, “as there exists an obvious harmony between our physical and social constitutions, the necessity of intercourse between all the members of the human family is one of the final necessities of our race” (“Report on the Quarantine Laws,” Board of Health, p. 64); in other words, that “the diseases supposed to be contagious by our predecessors, *cannot be contagious*, because such a supposition is at variance with *a theory (of their own invention)* that there exists a necessity of intercourse between all the members of the human family;” and therefore all quarantine laws ought to be abolished. But are not small-pox, measles, scarlatina, hooping-cough contagious? And as regards “the necessity of intercourse between all the members of the human family,” were we to consult the Chinese, the Hindoo, the Peruvian, the Mexican, the Caffre, the Negro, the Turk, the Morocene, they would unhesitatingly tell you that such an intercourse

is sure to end in their destruction. Under a Trajan or an Alexander, an Antonine, or even an Augustus, the world no doubt was benefited by an universal intercourse between all the members of the human family *then known*, and such an intercourse was highly beneficial to humanity; but the kind of intercourse established by the Clives and Pizarros is of a very different nature from that of Alexander and Trajan. Civilization is the direct result of artificial wants, the gratification of which can alone be met by a free and unrestricted commerce. By violence an empire may be overthrown, and by rapacity its inhabitants may be deprived, not only of their land and property, but even of their natural rights as men, as in India under the administration of England; but all these crusades have no reference whatever to an ameliorating of the condition of mankind; they simply form episodes in the history of the human race, respecting which historians take extremely different views. The conquests of Mexico and Peru and India form episodes in the respective histories of Spain and Britain by no means flattering to the character of these nations.

CHAPTER VII. ON THE DECOMPOSITION AND METAMORPHOSIS OF ANIMAL BEINGS, AND ON THE INFLUENCE THEY EXERCISE OVER THE SOIL AS A HABITAT FOR MAN.

During life animal bodies undergo continual decomposition and recomposition; life is in fact a perpetual metamorphosis. Whilst alive, the products of vitality (*excreta*) are returned to or deposited in or on the surface of the earth, and carried by drainage and other means into the nearest water, river, or stream; we have lived to see them thrown *en masse* into a tidal river the waters of which serve at the same time to furnish most of that required for the economy of a vast capital and many surrounding towns; in the same country the cesspools and dead-wells constructed to receive the liquid and solid *excreta* of dwelling-houses are not unfrequently constructed close to the pump-well which is to supply the inhabitants with pure water for culinary purposes.

To these extraordinary facts I shall shortly return. They show the extent to which intelligent, talented, shrewd men may suffer themselves to be deluded and led aside from the path pointed out by common sense, more especially when crotchets are substituted for principles; when men fancy that in following out some imperfectly-observed inquiry, they are imitating nature —that nature which is ever consonant with herself, which created all animals, and which knows how to dispose of their excreta when living, and of their remains when dead, without detriment to the living. The Caffre, the Hottentot, the Bosjieman, the North-American Indian, the Bedouin, require no sanitary arrangements, no laws regulating, nor staff to carry out a code of theoretical Utopian schemes, sure to revert on the heads of those foolish enough to employ them; the excreta deposited on the earth disappear, so do also the remains of animal life. We never hear of any pestilence, fever, scurvy, dysentery, small-pox, hooping-cough, malignant sore-throat, or other zymotics, originating amongst them. It would, indeed, almost seem that such evils do actually owe their origin to human agency and to human civilization; where civilized man makes his highest endeavours, there his most signal failure occurs; experience teaches him nothing; the insolence of wealth naturally leads to the contempt of all knowledge derived

from means otherwise than national and native. In Britain the muddy banks of rivers, which in Holland and Belgium are covered with vegetation, lie exposed, festering in the sun's rays, the fertile source of agues and other diseases; here they are being continually exposed, or alternately covered with water, which is then allowed to evaporate; this mud is not suffered to rest, but stirred up in a variety of ways, as best suits the convenience of the parties interested. It suits, for example, the proprietor of a long-neglected drain or sewer, cesspool or filthy stagnant canal, or a common ditch, which once was a clear rivulet, to cleanse it out. He selects the warmest weather and the longest day for that special work, or he spreads the contents of the cesspools of half a century's collection on the fields, suffering it to remain there for weeks, thus rendering the roads all but impassable. The selected lives of the finest men in the kingdom, petted, fed, clothed, and lodged at the public charge, without anxiety or a care for to-morrow —the Guards of England—die under his fostering hand, in the ratio of three to one of the care-worn and toil-exhausted peasant, miserably fed, scantily clothed, badly lodged, and full of anxiety for the morrow. Now, how comes this? Simply, I believe, from this—that man, knowing much better than nature, has chosen to take her place, to do her work clumsily, and to fancy that he is doing it well; to interfere, and not to carry through the works he has undertaken. What other proof can be required than the fact that, on the frontiers of the Cape of Good Hope, in the healthiest country in the world—a fact proved not only by the statistics of the celebrated statistician, Major Tulloch, but by the evidence of all medical men who have resided there,—where the mortality is not a half of what it is amongst the most favoured counties of England—in such a country, where every man might have had a mile square of ground to live on, military arrangements contrived to break down whole regiments of the healthiest young men England could produce.[29]

The Dutch Boers and Hottentots were astonished, as well they might be. "Towards the end of June, 1836," observes Major Tulloch, "very decided symptoms of scurvy began to manifest themselves among part of the 75th Regiment at Fort Armstrong, and subsequently extended to most of the other stations along the frontier. The total number of cases reported either as scorbutus or purpura, were 134, of which 4 proved fatal; the others readily yielded to change of air, with improved diet and accommodation." As was to be expected, the Hottentot troops, on the same ground, being left to act generally in accordance with the dictates of their own common sense, wholly escaped the disease.

Let us now briefly review the means adopted by nature for the disposal of these

Let us now briefly review the means adopted by nature for the disposal of those remains so embarrassing to the civilized, so innocuous to man living in a semi-barbarous or savage state, and which prove to the former a source of infinite expense, discomfort, and disease. The problem has reference to the soil, to the air, to the water; to the condition of all three as regards the preservation of animal life generally, man included.

I have already remarked in a preceding chapter, that all organized beings after death undergo a change, in consequence of which their bodies, as such, disappear from the surface of the earth. In a short time after the event, animal matters lose their cohesion; they are dissipated into the air, leaving only the mineral elements they had derived from the soil. The change commences immediately after death: with the aid of moisture and exposure to the air, the bodies of animals, as well as plants, undergo changes, the last of which are[30] the conversion of their carbonic acid and of their hydrogen into water, of their nitrogen into ammonia, of their sulphur into sulphuric acid. Thus, their elements assume or resume forms in which they can again serve as food to a new generation of plants and animals. “The same atom of carbon which, as the constituent of a muscular fibre in the heart of a man, assists to propel the blood through his frame, was perhaps a constituent of the heart of one of his ancestors, and any atom of nitrogen in our brain has perhaps been a part of the brain of an Egyptian or of a negro.

“As the intellect of the men of this generation draws the food required for its development and cultivation from the products of the intellectual activity of former times, so may the constituents or elements of the bodies of a former generation pass into, and become parts of, our own frames. The proximate cause of the changes which occur in organized bodies after death is the action of the oxygen of the air on many of their constituents. This action only takes place when water—that is, moisture—is present, and requires a certain temperature.”

The great agent in all these changes is oxygen, as has been already sufficiently explained when speaking of the decomposition of vegetables after death. I shall first attend to the influence these changes have on the soil as producing agents, intended to restore to the soil those vivifying powers which it never seems to lose when man interferes not; and lastly, to consider briefly its influence on man himself.

The development of scarcely any plant can be imagined without the assistance of nitrogen or of azotized materials. Now, under certain conditions known to all

botanists, this azote must come from rain water, either in the form of atmospheric air, or under that of ammonia. Chemists have, I think, proved that it originates in the ammonia contained in the atmosphere, and not in the azote as it naturally exists in the air. The problem is put and solved in this way by Liebig, "Let us consider a farm suitably conducted, and of an extent sufficient to maintain itself, ammonia exists there in a sufficient abundance in rain water and snow; in the water of most fountains; it exists in the air in abundance, and is being constantly renewed by the decomposition of animal and vegetable bodies, and is restored to the soil by the rain, and then absorbed by the roots of plants, and produces, according to the organs, albumen, gluten, quinine, morphine, cyanogene, and a great number of other crystallized combinations."

The most decisive proof of the part played by ammonia in the nourishment of plants is furnished us by the use of manure in the cultivation of cereals and green forage. According to the distinguished chemist so often quoted in this essay, animal manure (*fumier*) acts solely by reason of its production of ammonia. The history of the Peruvian guano, a substance so highly ammoniacal, proves all these assertions; this celebrated manure, which fertilizes a soil (the Peruvian) of the most remarkable sterility, consisting mainly of white sand and argil, is composed chiefly of urates, urate of ammonia, oxalate of ammonia, phosphate of ammonia, carbonate of ammonia, and some other salts.

Thus did the ancient Peruvian, like the Chinese, stumble on the solution of problems involving the fate of millions by simple experience alone, wholly unaided by science, which steps in afterwards and gives the *rationale* of the process; teaches us that all wheats do not equally abound in gluten; that rice is poor in azote; potatoes equally so. Practical agriculturists still find difficulty in applying with success the processes recommended by the chemist; but these, no doubt, will gradually be overcome.

"Since we find azote[31] in all the lichens which grow on basaltic rocks; that the fields produce more azote than is brought to them in the shape of aliment; that we meet with azote in all soils (*terrains*), even in minerals which happen never to come in contact with organic matters; that in the atmosphere, in rain-water, and in that of fountains or springs, in every description of soil we meet with this azote under the form of ammonia, as a product of the slow combustion or of the putrefaction of anterior generations; that the production of azotized principles greatly increases in plants with the quantity of ammonia presented to them in animal manure,—we may in all safety conclude that *it is the ammonia of the*

atmosphere which furnishes the azote to plants.

“It results from the foregoing32 that the carbonic acid, the ammonia, and the water, include in their elements the conditions necessary for the production of all the principles of living beings. These three bodies are the ultimate products of the putrefaction and of the *eremacausis* (slow combustion) of all animal and vegetable races. All the products of the vital force, so numerous and so varied—all after death return to the primitive forms in which they first appeared or from which they originally sprung. Death, the complete dissolution of a generation, is always the source of a new generation.”

Equally curious, but foreign to my present purpose, is the inquiry into the sources of the inorganic principles in plants and animals. These sources were inappreciable until a more refined chemistry appeared. Sea-water contains only the 1/12,400th of its weight of carbonate of lime, and yet this quantity suffices for the production of the essential components of the shells of myriads of crustaceans and corals. Whilst the atmosphere contains but 4/10,000ths to 6/10,000ths of its volume of carbonic acid, the amount in sea water is more by a hundred times, and yet in this medium we find another world of animal and vegetable life, which finds re-united in the ammonia and carbonic acid the same conditions which enable human beings on the surface of the solid earth (*terra firma*) to live and to maintain their species.

It would even seem that the essential constituents of some organs have altered in the course of ages, without affecting, or being materially affected by, the principles of life. Thus it would seem that fossil bones contain the fluate (fluorure de calcium) of calcium in much larger quantities than the bones of recent animals; and the same remark has been made in respect of the composition of the crania of men found at Pompeii. They resemble in this respect the antediluvian fossil remains.

Thus, imperceptibly, as it were, proceed the grand operations of nature, and if accidentally any vast collection of excreta should happen to be found, as in the guano islands of the dry regions of America, they seem not to affect the life or health of those animals which repose on them. It is the same in the dry regions of Southern Africa, where sheep and cattle, in order to protect them from wild animals, must, on the approach of evening, be collected into a fold or kraal, surrounded by a strong fence of the mimosa, and carefully shut in. On this surface, of no great extent, sheep and oxen stand or rest for the evening: their

excreta accumulate, but do not putrefy, for the air on the kraal is pure comparatively, and never injurious to the sheep or cattle; the surface of the kraal is, moreover, generally dry, even when the soil may be accidentally inundated by rain, which, when it falls, as it does occasionally, descends in torrents. From the African soil is thus withdrawn by man the excreta of all the domestic animals; the semi-barbarous Boer never returns it to the soil, and thus the loss is permanent; but it would seem that this loss, caused by man's interference, in no shape, as far as can be observed, affects the fertility of the soil, called on to reproduce only the native pasture, or the wild herbs natural to it. It is otherwise when man demands from the soil heavier exhausting crops of wheat and hemp, tobacco, &c.: his interference with nature's balance must be gone into, or soon his hopes of a harvest would be in vain. Then comes the theory of manures, a theory beset with difficulties, and which, besides involving man in much labour and expense, is productive, or presumed to be on sufficiently probable grounds the cause, of some, if not of many, of the diseases which afflict humanity. However this may be, whatever be the extent to which a dense population and a neglect of the so-called sanitary regulations subject man to infirmity and disease, one thing is certain—he has interfered with nature's balance, and must take on himself the whole task. If he shuts up a harbour mouth, refusing entrance to the tide, confining within the harbour a portion of that ocean water which nature intended should be constantly agitated by tides and currents, he may expect as results that the shores of that harbour will soon become uninhabitable by man. All animals instinctively shun the sick, leaving them apart; man crowds them together into close, ill-ventilated hospitals, sweeping off in hundreds those whom the battle had spared.

It were foreign to the object of this work to enter more fully into the history of that dissolution of animal structures which forms so important a part of the materials we call manure, destined to restore to the soil that which artificial crops had deprived it of. Every part of animal bodies owes its origin to vegetables or plants, no part being formed by the vital force, and thus all the remains of animals of necessity form manures.

On the management of these, man's civilization depends; without agriculture there can be no dense population; without the dense population there can be no civilization. On these points many remarkably erroneous opinions have been, and still perhaps are, maintained even by practical men, who nevertheless are often in error—merely, it is true, as to the theory on which they fancy they act, more rarely as to the practice they have from experience adopted.

In calmly considering this important question—the right management of manures composed of the excreta or the remains of animal and vegetable life, it becomes evident that several problems, atmospheric as well as terrestrial, remain yet to be solved. The surface of the soil, as modified by man's labour, presents itself under a very different aspect to what nature intended it to be. A lake may be drained with much advantage to a country, but the surface so exposed cannot be too soon cultivated, to prevent the spread of fevers sure to arise from the decaying, fermenting, and putrefying of the lower forms of animal and vegetable life thus brought into existence, especially when aided by those epidemic constitutions of the atmosphere striking directly at man's existence on the earth.

For civilized man there is, there can be, no repose. There are forces in nature against which, with all his industry, he may never be able to prevail. The tropical forest returns upon him the instant, as it were, that he ceases to hew it down, obliterating in an incredibly short time all traces of human labour. The lands of Western France can scarcely be secured from the inroads of the sands driven by western gales towards the interior; the bog is checked only by constant labour, and the hill where once the heath grew spontaneously, can only be retained in a green and grassy condition by the constant watchfulness and labour of men. Twenty years of neglect suffice to restore the heath, and to sweep away all vestiges of human culture.[33]

CHAPTER VIII. EARTH, AIR, AND WATER IN RELATION TO MAN—HOW MODIFIED BY HIM—RESULTS OF THAT MODIFICATION—ACTION AND REACTION.

§ 1. The question of acclimation is not confined merely to man's transfer from one country to another, and to his attempts to accommodate himself to the new locality, to the altered circumstances of his adopted country. As civilized man traverses the earth in search of new abodes, he carries with him the arts of social life, and especially the art of agriculture, by which alone he can exist in congregated masses: agriculture, which forms indeed the very basis of civilization.

Whether we view man as a native of the land or a stranger, he cannot evade this question; for even as a native and as an individual of a race whose presence on the soil he may inhabit precedes the records of authentic history, if he form a portion of civilized society he receives from his ancestors or predecessors a system he is bound to improve, or at least to maintain, so that he shall live and thrive, not as the beasts of the field, but as a member of a civilized people. When a hunting tribe of North American Indians, a horde of Bedouins, or Hottentots or Caffres, a Turcoman family, or a gipsy encampment, a Cape Boer, or an Australian sheep-farmer, sit down by stream, or valley, or lake, they no more influence the soil than a troop of antelopes or buffaloes. Nature's great processes go on unaffected: they deteriorate, it is true, by respiration, the superincumbent atmosphere, but not more than any equal amount of animal life. This deterioration the wild plants around, sown by nature herself, speedily removes; the oxygen consumed by savage man and the animal life around, equally wild, is speedily renovated by vegetation, and the oxygen they remove from the atmosphere and the carbonic acid they pour into it, rapidly and constantly recover their equilibrium under the influence of vegetation. Thus, neither the earth (soil), air, nor water, is in any way influenced by his presence, nor is he in general affected by these; there is no reciprocal influence for good or bad: he cuts down no forests, grows no wheat, or but little, makes no canals, drains no marsh-lands, poisons no rivers; the refuse of his dwellings, the excreta of such a population, are not sensibly perceived, even if allowed to rot and waste away on the surface—a practice prevalent with most if not all wild and uncultivated

people; it rapidly disappears, disintegrated by processes in which the lower forms of animal life take a part. Now, contemplate the picture civilized man presents, and see him in direct antagonism with nature! The plants of nature's sowing are rudely torn up with the plough and destroyed, the fields are forced to yield crops by which he lives, and what he takes from the soil must, to use the language of chemists, "be restored to it:" the excreta of man and animals, the refuse of dwellings, the deteriorated and poisoned liquids, the products of manufactories, are collected into heaps, to rot on the surface of the soil, before being dug into it; or are thrown into the rivers, to poison, in a certain sense, the waters on which man lives, rendering their banks, if not pestilential, at least most unpleasant as human abodes; canals are dug, vast reservoirs are formed, which in time give rise by mismanagement to fevers, intermittent and others; the minerals of the earth are quarried and placed on the soil, mines are dug, and from them waters are discharged into the neighbouring streams, strongly poisoned with the metallic ores. To imagine that an influence thus affecting earth, air, and water can proceed and increase without affecting human life, can be overcome by habit, does not require to be met by counter-influences originating in the experience and reasoning of man himself, is a supposition which the history of large cities refutes. The influence is reciprocal. When man thus acts on the three elements of nature by which he lives, they react on him, and it is this reaction he is called on to meet and to overcome as best he can. It is a question of reason and experiment—that is, of science and of simple observation; simple observation and experiment taught the native Peruvians the value of guano, for science had at that time no standing on the American continent; and now the chemist steps in and explains why it was that the experiment proved successful. Whether his explanation be satisfactory or not, touches not the question; though proved to be erroneous in a single instance, as it possibly is in regard of this very Peruvian guano, science stands on too secure a basis to require any defence from me.

It is one of the conditions of civilization, that man must everywhere accept the social system within which he lives. Whether a dweller in detached cottages and farm-houses, or congregated into townships and villages; collected in masses, as in towns and cities, his endeavour is to protect his dwelling from all that is offensive and from whatever may prove injurious to the health of himself and family. An ancient adage tells us not to act contrary to nature; but as nature reveals nothing to us, as her intentions can only be read by the lights of science and reason, or science based on observation and experiment, whence human reason draws deductions conformable with its power, so is it most difficult for man to say what is best to be done under all circumstances. When a man builds a

cottage, a house, or a palace, after duly attending to the surface-drains, he constructs near his dwelling, sometimes beneath it, a cesspool and a dead-well, the former intended to receive the more solid excreta, the latter the soil-water of the kitchen—the water, in fact, used in the domestic economy of the house. If the dead-well or pit dug to receive the soiled water of the house be sufficiently deep, it filters through the soil, and thus requires no clearing out—if not, it overflows the court or garden, and speedily renders the place uninhabitable. The cesspool, if deep enough and properly secured, remains for many years unknown and unperceived, until filled; it may even be forgotten altogether, and its very existence remain unknown, until disclosed by accident; but whatever be its age or condition, so soon as its contents are exposed to the air, it is found to have continued unaltered; and if spread on the fields, as I have seen done, renders the vicinity for some time unendurable, thus proving the sagacity of the Jewish legislator in his instructions to that people to whom he gave laws and regulations to serve them for all time to come.34

If the adage I have quoted above be true—namely, that we must not act contrary to nature—there is another of the truth of which we feel more assured. It is this: whenever man interferes with nature, he must take the whole matter on himself, and be prepared to meet every contingency. Nature gave us streams and rivers more or less pure, whose banks are more or less salubrious. If man pours into these streams and rivers the refuse of towns and cities, he must be prepared to meet the result of the experiment. It may be good—it may be bad to him: this he cannot know beforehand; but reason tells him that the experiment is likely to prove injurious. It may be less injurious than burying the excreta in cesspools under his house, or court, or garden;35 but this I doubt. In the meantime, how does civilized man protect himself from a source of disease respecting which there never was a doubt—the natural humidity of the soil on which he has erected his dwelling, in which he sleeps and lives? To meet this evil he forms surface drains around his house and garden and court. Into these collect the humidity natural to the soil, as well as rains of heaven. These drains, adulterated by no intermixture with the refuse of house and stables, terminate in the nearest streams, and serve to maintain these streams and rivers into which they flow at their natural standard.

Thus, before it was discovered that the best way of dealing with these difficult questions was to break down the distinction between drain and sewer (thus poisoning, probably for all time to come, the air of towns and cities), construct a sewer which soon becomes a cloaca to receive all, and in open day and above

ground throw the contents into the nearest stream—imitating old Rome, without knowing anything of Rome's municipal economy, our forefathers drew a marked and clear distinction—1st, between drain and sewer; 2nd, between a cesspool and a dead-well; 3rd, between the excreta of man, which they knew to be offensive, and that of animals, which all were well aware are innoxious: the latter they restored to the fields, the former they disposed of as best they could.

Society, having rejected in this instance the experience of their forefathers, enters now on a new phasis. Nature, about which they talk so much, will not suffer them to rest half way. Bad odours pervade the streets, courts, and houses: rivers can scarcely be approached. Chemists affirm that that which is thrown into the sea should be returned to the land. It is this question, in so far as it bears on the matter discussed in this chapter, I shall now briefly discuss.

There lie before me the "Letters on Chemistry" of an illustrious German chemist.[36] They contain the expression of the latest scientific results hitherto attained. Whatever view those who follow us may adopt, we must in the meantime accept, to a certain extent, of those contained in these "Letters." A phenomenon must be accepted as a fact until refuted by another; and the last experiment, until refuted, expresses the nearest approach to that truth which, up to the moment, man had been able to attain. Simple observation tells man many truths. It shows him that out of grass, herbivora, or grass-eating animals of all kinds—from the timid hare to the swift and powerful horse—from the fierce buffalo to the sagacious and irresistible elephant—find the means for forming muscle and bones, viscera and skin. Out of a similar food man himself, though no doubt omnivorous, can also derive the means of support. The rice-eating population of India are not deficient in energy; whilst it is equally certain, though less surprising, no doubt, that out of that which once was a living animal, man and the carnivora derive a considerable part of their subsistence.

No experiments can set aside these simple views, which indeed form the basis of all inquiry; but civilized man, as I have shown, appeals to the soil mainly for support. He trusts to the cerealia, and to those exuberant and abundant crops of legumina and of grains required for the support of herds of animals, which the uncultivated field could never maintain. Hence arose agriculture, the most useful of all the practical arts—not yet a science, but likely in time to become one.

Chemists assert—and I see no reason to doubt their experiments—that the ash of the blood of graminivorous animals is identical with that of the ash of grain; the

incombustible constituents of the blood of men, and of such animals as consume a mixed food, are the constituents of the ashes of bread, flesh, and vegetables; the carnivorous animal contains in its blood the constituents of the ash of flesh.37 All these substances ought to be found in grass alone.

In these processes it would seem that phosphoric acid plays a most important, and, as it would seem, an essential part. To this I shall return: at present I merely consider man's influence on the soil or earth he lives on, what he derives from it, and what he returns to it, and in what form it is and ought to be returned. If it be true that without trees there would be no underwood, no corn, and no crops,—for trees attract the fertilizing rain, and cause the springs perpetually to flow which diffuse prosperity and comfort,—then assuredly man ought to be most careful in interfering with nature. It is the remark, I think of the illustrious Humboldt, that when the white man took possession of certain districts of North America, vast forests prevailed everywhere. On taking possession, experience showed that agues prevailed, and that wheat might be grown successfully. The forests have been now destroyed, and agues have disappeared; but phthisis pulmonalis prevails, and wheat no longer grows to maturity. We interfere with the soil as nature made it when we force it to produce from one acre the natural produce of ten; we interfere with the processes of nature when we load the air with the products of thousands of furnaces, manufactories, and the poison exhaled from poisonous rivers and brooks; and we interfere with nature when we alter the constitution of those streams and rivers from a natural to an artificial state, loading them with the refuse of our artificially-drained fields, &c.

Let us listen to Liebig on a matter to which he has given the utmost possible attention:—

"Experience in agriculture shows that the production of vegetables on a given surface increases with the supply of certain matters, originally part of the soil which had been taken up from it by plants—the excreta of man and animals. These are nothing more than matters derived from vegetable food, which in the vital processes of animals, or after their death, assume again the form under which they originally existed as parts of the soil. Now we know that the atmosphere contains none of those substances, and therefore can replace none; and we know that their removal from a soil destroys its fertility, which may be restored and increased by a new supply. Is it possible, after so many decisive investigations into the origin of the elements of animals and vegetables, the use of the alkalies of lime and the phosphates, that any doubt can exist as to the

principles upon which a rational agriculture depends? Can the art of agriculture be based upon anything but the restitution of a disturbed equilibrium? Can it be imagined that any country, however rich and fertile, with a flourishing commerce, which for centuries exports its produce in the shape of grain and cattle, will maintain its fertility if the same commerce does not restore, in some form of manure, those elements which have been removed from the soil, and which cannot be replaced by the atmosphere? Must not the same fate await every such country, which has actually befallen the once prolific soil of Virginia, now in many parts no longer able to grow its former staple productions—wheat and tobacco? In the large towns of England the produce both of English and foreign agriculture is largely consumed. Elements of the soil indispensable to plants, do not return to the fields; contrivances resulting from the manners and customs of the English people, and peculiar to them, render it difficult, perhaps impossible, to collect the enormous quantity of the phosphates which are daily, as solid and liquid excreta, carried into the rivers. These phosphates, although present in the soil in the smallest quantity, are its most important mineral constituents. It was observed that many English fields exhausted in that manner, immediately doubled their produce as if by a miracle when dressed with bone earth imported from the Continent. But if the export of bones from Germany is continued to the extent it has now reached, our soil must be gradually exhausted, and the extent of our loss may be estimated by considering that one pound of bones contains as much phosphoric acid as a hundredweight of grain."

Many practical farmers, I am aware, still doubt the facts and theories of chemistry as applied to agriculture; with them I am free to admit that agriculture is not a science as yet, but an experimental art. With this I have nothing to do directly, my object being to show in this chapter in how far civilized man modifies and influences the soil on which he lives. He, the practical farmer, clings to farmyard manure, which he collects in heaps in his farmyard, or by the roadside, exposed to every change of weather, to drenching rains, to summer heat, and winter's cold; from it run in streams over the roads the liquid parts of the manure, carrying with them the soluble salts; out of what is left when it has become rotten he hopes to restore to the field what it lost during the previous crop, and to a certain extent he succeeds; on the other hand, the chemist argues that the grand object of modern agriculture is to substitute for farmyard manure, that universal food of plants, their elements, obtained from other and cheaper sources retaining its full efficacy; and this can only be done when we shall have learned, what as yet we know but imperfectly, how to give to an artificial mixture of the individual ingredients the mechanical form and chemical qualities

essential to their reception, and to their nutritive action on the plant; for without this form they cannot perfectly supply the place of farmyard manure. All our labours must be devoted to the attainment of this important object.

However this may be, and however it may be explained by the chemists, it must be admitted that to the accidental discovery of bone manure England owes many turnip crops, and to the introduction of guano from Peru and Ichaboe crops of wheat which no other manure as yet known could have produced. Peruvian guano, the best of all, is the excreta of a sea bird; these excreta, placed in a clear and perfectly dry atmosphere, have been exposed for centuries to a tropical sun; no rain falls on the heaps, trodden down only by the gentle feet of the birds themselves.

That out of such a product there should arise so excellent a manure surpasses all previous reasoning derived from mere science.38 It is obvious, then, that much still remains to be discovered. Were any proof of this required, we might refer to the agriculture of China, where, as has been reported, human excreta alone are used as manure, and with a success unequalled in any other part of the world. In that singular land they have discovered much, or using perhaps the discoveries of preceding races, have turned them to the best account. Their agriculture is said to be perfect.

With such a system of manure and such a population one might predicate a condition of earth, air, and water, incompatible with human life. Now the very reverse happens, at least, in so far as regards the Chinese themselves.

No land so teems with a population strong, active, and in robust health; true, it does not suit the European constitution; fever and dysentery sweep off the troops and sailors of European nations who visit the Celestial Empire for the purpose of trade or of plunder. There is a something unknown in the climate unsuitable to the European; the condition of the earth, air, and water of China, is fatal to him. In which of these does the noxious element reside—in all or in none? This is possible; but man in the meantime must decide by what he knows and sees. Here is a land teeming with life; on land, as on its waters, millions live; but that life, as regards man, is confined to the Chinese race, and is unsuited to the European; as regards the soil, manured in so strange a manner, it also is Chinese. Is it that we, generally speaking, spread the material in a liquid and vastly diluted form over the fields, whilst they manipulate and remove from it all moisture? There may be something in this, for it is known that organic compounds, above all, are

most susceptible of change by the least perceivable alterations in their constituents. Agriculture is both a science and an art.

“The clearing of the primeval forests of America, facilitating the access of the air to that soil, so rich in vegetable remains, alters gradually, but altogether, its constitution; after the lapse of a few years no trace of organic remains can be found in it. The soil of Germany, in the time of Tacitus, was covered with a dense, almost impenetrable forest; it must at that period have exactly resembled the soil of America, and have been rich in humus and vegetable substances; but all the products of vegetable life in those primeval forests have completely vanished from our perceptions. The innumerable millions of molluscous and other animals, whose remains form extensive geological formations and mountains, have after death passed into a state of fermentation and putrefaction, and subsequently, by the continuous action of the atmosphere, all their soft parts have been transposed into gaseous compounds, and their shells and bones, their indestructible constituents, alone remain to furnish evidence of the existence of life continually extinguished and continually reproduced.”

If these facts are to be depended on, they explain much of the influence which man exercises over the soil, and of its reaction on himself; the hay ague or fever is the produce of his own hands; when he leaves *on the surface* millions of tons of fermentable and putrescible organic remains, he prepares for himself some at least of the diseases which are to follow. It is possible that epidemic influence, over which he neither has nor can have any control, might be greatly modified, and its evil effects abated by prudent action on his part. Typhus fever, the scourge of modern Europe, may not originate in any condition of the soil produced by man, but it sweeps thousands in the prime of life from the earth when placed in circumstances clearly dependent on man himself. Ten thousand young men are lodged in a barrack; speedily hundreds of these are swept off by typhus or consumption of the lungs; now something causes this, and the cause may rest with man himself. Pestilence and typhus follow in the train of famine; if they originate in fermentescible and putrescible substances, all these were present prior to the famine, and yet were not equal to the production of the maladies. Next comes famine, and prepares the way for malaria to do its work. The question, as may be already seen, is not so simple as chemists supposed it to be. The number of substances occurring in nature which are truly putrescible is singularly small;39 but they are everywhere diffused, and form part of every organized being. To form an idea of what this amounts to, we have but to reflect on the life which naturally exists on the earth, and on that which is the result of

man’s social condition. Let but the acre of heath or bog, even of pasture, which in its natural state supports so little of what lives, be converted into a garden, a wheat field, a nursery, and see what an amount of putrescible matter is the result. Let that spot on which nature has placed a single peasant’s family be converted into a city, and reflect on the influence man exerts on that soil. It is, I believe, a fact universally admitted, that all those substances which destroy the communicability or arrest the propagation of contagions and miasms, are likewise such as arrest all processes of putrefaction or fermentation; that under the influence of empyreumatic bodies, such as pyroligneous acid, which powerfully oppose putrefaction, the diseased action in malignant suppurating wounds is entirely changed; that in a number of contagious diseases, especially typhus, ammonia, free or combined, is found in the exposed air, in the liquid and solid excreta (in the latter as ammonio-phosphate of magnesia); such being the case, it seems impossible any longer to entertain a doubt as to the origin and propagation of many contagious diseases.

“Finally, it is an observation universally made, and which may be regarded as established, ‘that the origin of epidemic diseases may often be referred to the putrefaction of great masses of animal and vegetable matters; that miasmic diseases are found epidemic, where decomposition of organic substances constantly goes on, in marshy and damp districts. These diseases also become epidemic, under the same circumstances, after inundations, and also in places where a large number of persons are crowded together with imperfect ventilation, as in ships, in prisons, and in besieged fortresses.’[40] But in no case may we so securely reckon on the occurrence of epidemic diseases, as when a marshy surface has been dried up by continued heat, or when extensive inundations are followed by intense heat.”

If we admit these facts we shall be less surprised at the ravages committed by fever, when, after great battles, the wounded are placed in the hospitals of large cities, as in Brussels after Waterloo, in Bilboa, Vienna, &c. Hospital gangrene, the scourge and terror of the wounded, soon shows itself, and cannot be arrested by any known surgical means. Much better were it for the wounded that they had been left on the field of battle. An erroneous opinion prevails, that it is to the presence of the infusoria that the evil influences are to be traced; they, on the contrary, whilst alive, act a beneficial part. The excreta of man whilst putrifying never exhibit the presence of microscopic animalculæ, whilst we find abundance of them in the same matters when in a state of decay. “A wise arrangement of nature has assigned to the infusoria the dead bodies of higher orders of beings for their nourishment, and has in these animalcules created a means of limiting to

for their nourishment, and has in these animalculæ created a means of limiting to the shortest possible period the deleterious influence which the products of dissolution and decay exercise upon the life of the higher classes of animals. The recent discoveries which have been made respecting these creatures are so extraordinary and so admirable, that they deserve to be made universally known."

It is not to that which lives, but to that which has lived and is now dead, that we must look for the sources of those terrible fevers which destroy humanity in so many fine countries. Nor is it necessary that marshes be present, nor recently inundated lands. Egypt, annually inundated, is healthy at all times, but it is always cultivated; the desert also, which is never cultivated, and incapable of any cultivation, is also healthy. The Arabian desert which skirts the cultivated spots, converting them into so many oases, is perfectly healthy; on its soil the traveller may sleep securely; but let him cross the boundary of the water drain or stream forming the oasis, and sleep within the limits of that vegetation so delightful to look at, and violent fever is sure to overtake him on the morrow, so powerfully in this instance does nature react on man, when altering the soil, he prepares with his own hand the flowery path which leads him to the grave.

§ 2. *On the Origin and Action of Humus*.—To Liebig we unquestionably owe the first philosophical investigation into the history of *humus*. Innumerable difficulties and prejudices beset the inquiry. It was he who first showed that all vegetables and all their component parts, so soon as they cease to live, become liable to two forms of decomposition,—to putrefaction and to rottenness, that is to fermentation, and to that slow combustion to which Liebig gave the name of *eremacausis*, a Greek term, expressing by its original meaning the fact of slow combustion, to which the illustrious German likened that process which we commonly express by the term of *pourriture*, or rottenness. By this last-named process the combustible parts of bodies in decomposition combine with the oxygen of the air.

The decomposition of the rotting of the woody fibre is attended with this peculiarity—when in contact with the air, it converts the oxygen into an equal volume of carbonic acid; so soon as the supply of the oxygen ceases the rottenness stops. Now remove this carbonic acid, and add a fresh supply of oxygen, and the rotting commences, and carbonic acid reappears. The presence of water is essential to this change; the substances called antiseptic arrest it at once. Now the woody fibre in this condition of slow combustion or rottenness is

precisely what we call *humus* or *ulmine*.

The functions of this humus are no doubt remarkable, and in respect of it some agricultural theories have been formed, resting on no solid basis. What seems to be tolerably well ascertained is, that in a soil permeable to air, the oxygen of the atmosphere continues to act on the humus, giving origin to carbonic acid, and thus furnishing an atmosphere for the roots of plants growing in that soil. The springing of the roots themselves seems to depend on the presence of this atmosphere; hence the labour and pains to pulverize the soil, and to give access by such processes to the atmospheric air. At this period of their growth the roots perform all the offices of their leaves which are ultimately to appear; and soon the plant has two sets of nourishing organs, the roots and the leaves. In hot summers plants derive their carbonic acid wholly from the air.

Thus gradually is formed that humus or ulmine to which agriculturists attach so much importance; that vegetable mould supposed to be the richest of all soils. But where it forms, a kind of putrefaction continually goes on; the soil is influenced deeply as a residence for man. No valetudinarian takes up his abode in the centre of a rich vegetation in hopes of recovering his health and strength, his elastic step, and freedom from lassitude and weariness; he, on the contrary, seeks other regions, where vegetation is scant, humus is not forming, and the soil is never turned over by human industry.

When vegetation is purely natural, that is when man does not interfere, the growth of plants does not in the least exhaust the soil. Look at the meadow and the virgin forest! Now chemistry explains this, or nearly so. But so soon as man *interferes*, he must be prepared to undertake the whole labour; if he acts on the earth, the air, and the waters, they will react on him, and sometimes with fearful effect. Beyond the processes she exhibits, and which he may read as best he can, she reveals nothing; all her secrets must be extracted from her by science, by philosophy, by the slow procedure of experiment and observation. A traveller from a distant land prepares to cross deserts of which he has had no previous *experience*; shortly he discovers an oasis, which to him seems a paradise, and he proposes resting for the night within its treacherous circle; but the wild Arab, the native guide, knows better, and explains to him briefly that the desert alone is healthy, and to rest a night within that seeming paradise is death. It is the Homeric tale of the syrens reduced to a reality; gorgeous decorated plants, sweet-smelling flowers, perfumes of Arabia, invite you to enter that island destined, should you unhappily accept the invitation, to prove the resting-place

of all your labours.

It may seem paradoxical to maintain that by cultivation we at times render the earth insalubrious, at times comparatively the reverse, but the fact is so. It was Humboldt, as I have already remarked, who said that when Europeans first emigrated to America, the soil of certain northern states was found equal to the growth of wheat, and ague afflicted the population. With the destruction of the forests, the agues have disappeared, and wheat can no longer be grown; in the place of agues men are now afflicted with pulmonary consumption. Whoever has seen the marshy and boggy land, at times a lake, at others a black tremulous morass, and compared it with the rich drained Polder, its neat and compact farm-house, exhaustless meadows, herds of cattle, and the contented air of its well-to-do proprietor, will at once perceive that whatever might be the evil, unless it were a something truly grievous, so delightful a metamorphosis of a spot doomed by nature to eternal sterility, entailed on man, that evil was fully compensated for by the results obtained towards man's happiness. There is, there can be, or at least there never was, any unmixed good on earth: the whole is a system of comparison and compensation; of profit or loss; of gains and drawbacks.

When the English army died off at Walcheren the inhabitants of the province were perfectly healthy, and could not comprehend the cause of the calamity. It was the same in the Crimea. Under other arrangements, those more consonant with common sense and experience, the results might have been different; still it is certain that masses of young men of immature years cannot be withdrawn from their native soil and parents' hearths without suffering severely the consequence of the every way unnatural position they are forced to occupy; unnatural physically and morally. Barrack-rooms are not homes. No varied society is to be found there; no amusement, no employment for mind and body; it is man cut off from all human industry and enjoyment; no solace when ill, no comfort under suffering: that young men with unformed constitutions should "die off like flies,"41 need excite no surprise.

To return: to modern science, above all to Liebig, the practical chemist *par excellence*, we owe the discovery of the true office of *ulmine* or *humus* in vegetation; it nourishes the plant before it is in a position to draw its nourishment from the atmosphere. The vegetation called antediluvian had this peculiar character, that it enabled the plant to be greatly independent of roots and soil; its broad-leaved foliage sought everywhere for food in the carbonic acid of the

atmosphere. Accordingly all the plants were remarkable for the smallness of their roots, which generally have disappeared, and are now no longer to be found.

Let me now consider briefly—keeping the same object in view, namely, its influence on man—what are the sources and results of that amount of hydrogen or azote which plays so important a part in the economy of all that lives.

An agricultural farmer at a distance from markets sufficiently remunerative, has a large field of turnips which he knows not how to dispose of. Not having cattle or sheep sufficient to consume these turnips, he addresses himself to drivers of sheep on the way to the markets, inviting them to turn their sheep into the field, and there remain until the turnips are consumed. Thus he hopes to restore to the field the azotized and other principles removed from it by previous crops, and to prepare the way for fresh and more productive and profitable crops. It is on the same principle that in many leases of farms (those called steel-bow) there is an express clause that the straw shall not quit the farm, but be consumed on it. The object of this is simply to restore to the soil what forced crops have removed from it. Man has taken on himself the task of growing on one acre the natural produce of many; to feed twenty men instead of one from off the same extent of soil; to live in crowded cities, drawing their provisions from the surrounding country, producing nothing of themselves; to feed millions where nature intended but a few thousands should exist; he has taken the task on himself and must carry it through, exposed to destruction at every false step, and at this moment exposed to the accusation by the medical authorities of England of deliberately rendering his farm-house, his homestead, his cottage, his mansion, his palace, a pesthouse, the propagator, if not the absolute generator, of all the wide-spread plagues and pestilences, from that which desolated Athens in the time of Thucydides; laid waste the Roman world when Justinian reigned; smote England in the most unhappy and disgraceful period of past history;[42] and now, appearing amidst the tents of an obscure Arab tribe, ignorant of agriculture, living with their flocks and herds on the desert, happily remote from the influences of boards of health, officers of health, and registrars-general, once more threatens Europe; he is accused, in fact, of being the involuntary but certain slaughterer of his little babes. So says the eloquent Registrar-General of England in one of his sanitary reports; he belongs, it is true, and this must not be forgotten, to the theory-loving fraternity,[43] a professor, in fact, of that conjectural art which heretofore despised statistics, and which now, by mistaking figures for facts, threatens to convert true science into a scheme of fictions

anything but brilliant. To the Chadwicks, the Gavins, and a host of others still more potent, but who always act through the agency of *employées*, we owe the affair of Luton and of Birmingham, of the disgraceful condition of the Thames and of innumerable other localities; the deodorizing schemes of Leicester and Bristol, the intercepting scheme of the Thames, and the network of officers of health, amounting to 2600, now spread over England for the benefit of this tax-loving country.

If you hope to raise a crop you must replace in the soil certain elements which previous crops have removed from it. So says Liebig, and to some extent the experience of mankind supports the view.

The refuse of men and urinals which English speculators recommend you to throw into the nearest river, or into the sea if you can, or at least to deluge well with water before throwing it over your fields, the Belgian farmer places as nearly as may be under ground until required. Of it he forms a compost, seemingly inoffensive as being in some measure buried, trapped, and mixed with house refuse, and other materials. This compost, to which he looks in due time for the restoration to his well-managed farm of that which abundant crops had removed from it, he spreads at convenient and suitable times on his ground, into which it is speedily dug; thus at every step he reverses the theories of the would-be agriculturists of England, and should it be said that the measures he adopts are injurious to his health, destructive to his family, sources of pestilence to the country, we have the sure and trustworthy statistics of a true statistician[44] to oppose to the wild theories and bold assertions of the needy adventurers and hired officials who, clamouring so loudly for place and distinction, have chosen for the field of their tactics broad England and her colonies.

CHAPTER IX. ON POISONS, MIASMS AND CONTAGIONS.

§ 1. Although the amount of disease and mortality traceable to accidents, to the ordinary atmospheric changes of which the thermometer gives us due information, to the habits of life and the effects of hereditary influence, be sufficiently great, it yet seems nothing when compared with the terrible inflictions occasionally and at uncertain periods visiting man, whether shut up, as it were, within the confined haunts of cities, or living apart in the open country, in situations where it might be reasonably imagined no such influences could reach him. The poison of typhus, for example, if it be a poison, spares none: in certain epidemics the citizen and the peasant suffer alike: the strong robust man in the prime of life is its special victim; cholera attacked the inhabitants of the remote and isolated cottage as certainly as the careful wealthy citizen, and with the same results. No mode of life, nor sex, nor age was security against it; no race, no locality.45 An inquiry into the origin of such influences is the most important to which man's attention can be directed. These terrible epidemics appear under various forms; sometimes it is by typhus or influenza, cholera or plague; even those diseases which seem to be endemic, or confined to a locality, assume the form of epidemical raging pestilences, and then disappear for a time. Thus the remittents and yellow fevers of tropical climates do not always put out their whole strength; there is a lull, a season of repose, when man, deluded by the security of a few years, hopes that at last the evil influence has disappeared for ever. Vain hope! It moves in cycles, like the typhus of temperate climates, falsifying all predictions. Thus, in Jamaica, the grave of so many noble English regiments, the fever, sometimes called remittent, sometimes yellow fever, exhibited its fitful attacks during eighteen years, in the following capricious manner, at a station called Port Antonio, about eighty miles from Kingston. At Stoney Hill Barracks, the disease was still more capricious.46 As the poison producing intermittents and remittents must be presumed to be always present, it is incomprehensible how it should at times cease its attacks on man, showing that another influence or element requires to be present to render its attack successful. Again, we find that within a limited range, a long residence in a land unhealthy to the stranger seems by acclimation to diminish if not entirely to eradicate the susceptibility to disease on the part of the latter; but this opinion must be received cautiously and with reserve, for the phenomenon may be partly

due to the difference in race, respecting which we as yet know but little. The banks of the Scheldt, the Polders of Holland, and the mouths of the Rhine, the Danube, and the Indus, are healthy to the natives of these districts; graves to foreigners. In all inquiries of this kind, these well-established facts must not be overlooked.

§ 2. When a chemical substance is applied externally or internally to the living tissues of an animal sufficiently strong to dissolve the affinity between them and the vital force, and to substitute for it other stronger affinities, the explanation of the phenomena is easy, and the coarsest chemistry offers a solution. The action of caustic potass, of concentrated sulphuric acid, present the examples of this kind of dissolution. Other substances alone poisonous when given in concentrated doses, are known to pass, when sufficiently diluted, through the blood, and be eliminated by secretion and excretion from the body: after causing disturbances more or less grave, more or less important, the combinations they form, if any, with the living organic molecules are overcome by the vital force, which then resumes its usual influence. Of such substances some pass off unaltered, others are decomposed, and the bases only appear in the secretions or excretions. Whilst passing through the lungs, certain of these vegetable salts combine with the oxygen of the air, and the respiration in consequence becomes slower, or in other terms, they diminish the production of arterial blood.47

Now, these salts48 when placed in contact with animal and vegetable substances, perform the same function as in the lungs: they take a part in the combustion going on, and, as in the living body, are converted into carbonates. Left to themselves for a time, from their aqueous solution, the acids composing them finally completely disappear.

Mineral acids and nonvolatile vegetable acids, as well as mineral salts with an alkaline base, have the property, when sufficiently concentrated, to arrest the whole process of this slow combustion;49 common salt, as is well-known, arrests putrefaction: so does alcohol.

The chemical action of certain other mineral salts is different, such as the salts of the peroxide of iron, of lead, bismuth, copper, and mercury. These are inorganic poisons. They combine with the tissues of the organs, and so destroy life. The mode of action of the poisons of prussic acid, strychnine, morphine, &c., is as yet unknown.

“But there exists a class of substances no less fatal than the preceding, originating in certain decompositions. In a preceding Chapter (III.) we have inquired into the origin of these poisons, and shown them to originate in fermentation and putrefaction. Let us apply the chemical principles regulating these processes to organic matters, to the products of the animal economy; all the elements of these matters are derived from the blood, the most complex of all existing substances. In decomposing, a poison is occasionally produced speedily mortal when it comes in contact with the blood of the living animal. The venomous principle produced by decomposing animal bodies is not always the same: that originating in certain German sausages is quite peculiar; the person who partakes of this fatal dish dies mummified; he does not rot or fall to pieces like those who perish from wounds received in dissecting-rooms; on the contrary, he dries up and withers, but does not putrify.50 Liebig, the discoverer of this poison and its effects on man, states that the venom is destroyed by boiling-water and alcohol, but that these do not absorb it.

Similar in the mode of action on the economy are the poisons of small-pox, plague, &c. The substances which arrest fermentation and putrefaction, also neutralize the power of these poisons; but the essence of these poisons has not yet been obtained in an isolated form, and thus nothing positive is known of its real nature. One thing seems certain; contagions, poisons and miasms are not living beings nor animalcules, any more than yeast. They may be, and probably are, produced by fermentation, but this is neither caused by nor terminates in the formation of living animalcules, to which all or any of these phenomena might be attributed.

A nice distinction has been drawn by a distinguished chemist between a contagion properly so-called and a miasm. When the disease-producing matter is the product of a disease, it is a contagion; if it be the product of putrefaction or of eremacausis of any substance, animal or vegetable,—does it act by virtue of its chemical character, and not of its condition (*etat*), in forming a combination, or in causing a decomposition, it is then a miasm.

The history of diseases so originating scarcely supports this view. Typhus, which at times seems to originate in a miasm, at times seems to assume a contagious character. The same may be said of yellow fever. But however this may be, the distinction applies to such diseases as intermittent and remittent fevers, which originating in a miasm, itself springing from the putrescence of animal or vegetable bodies, gives rise to disease which does not reproduce the miasm.

Now, between diseases so produced and those arising from contagion properly so called, there is this remarkable distinction: the blood once altered is no longer susceptible of the same contagion, whereas against miasms there is no such security.[51]

In every contagious disease, and perhaps even in those simply arising from miasms, there is an odour which fills the chambers of the sick, and is recognisable at once. Ammonia is very generally present, as it is wherever animal decompositions are going on, that is, putrefaction. The foul airs emanating from stagnant and neglected ditches is composed, as has been long known to chemists, of carbonic acid and sulphuretted hydrogen gases, and these are viewed by some as amongst the most dangerous of miasms. These gases may be destroyed by acid vapours now in common use.[52] From chemistry we also derive another valuable lesson in respect of substances directly destroying human life. The materials ready to undergo putrefaction, and thus to generate miasms, may all be present, and yet no miasms are given out, and man escapes; this security depends upon the absence of that third principle requisite to bring the others into activity.

Thus it happens that in his extensive and elaborate inquiries, Major Tulloch was continually met by difficulties which overthrew at once all existing medical theories, rendering it even probable that the supposed relation of cause and effect between marshes and miasms, and miasm and fever, was merely accidental. In what that third element consists, that immediately exciting power which urges on the decomposition to an extent it had not before attained, rendering that miasm mortal, or at least most dangerous, which heretofore the vital force was able to resist, has not yet been discovered.

Is it electricity? is it ozone?[53] or does it depend on some unknown principle in the elements of the atmosphere, for the detection of which we have no instrument? Does security in such cases depend on the presence in the atmosphere of some such principle as ozone? Whatever be the cause, the fact is certain; epidemics follow cycles of increase and decrease; like comets, they come and disappear at long intervals. Our business in the mean time lies with what is constantly present, in a more or less aggravated form—the malaria continually reproduced, always efficient in certain regions of the earth; in the overcoming of which, as I have endeavoured to show, well-directed human industry is far from unavailing.[54]

CHAPTER X. ON THE SERVITUDE OF RIVERS.

If the servitude of rivers be the noblest and most important victory which man has obtained over the licentiousness of nature,55 then assuredly ancient civilizations bear away the palm in this respect from the modern, and Britain must be permitted to occupy perhaps the lowest place in the scale of those empires and nations who, by their industry and knowledge, overcame the difficulties which the right management of river courses presents to civilized man.

More than forty centuries ago the Nile was completely at the service of the ancient Egyptians, and the prosperity of Babylon and Nineveh leaves no doubt as to the subjugation of the Tigris and the mighty Euphrates. To come to later times, the Rhine itself, even in the days of the early Roman emperors, must have been subjugated by the labours of the primitive Batavians, and the revolt of Civilis, with his Batavian legions, testifies as to the energy and intelligence of the race. And now by the patient industry of their descendants, that land, seemingly doomed by nature to be wasted on one side by the turbulent ocean, on the other by the great rivers which traverse it, presents a spectacle unequalled in the world. Even the despised Oriental race of China, that unsolved problem in the history of mankind, whose capital the combined forces of England and France now threaten, seems never to have had a difficulty in mastering the great problems which the necessity for the subjugation of rivers forces on civilized man; the Chinese waters have been turned to the most profitable account; their deltas seem healthy, and abound with life, with Chinese life, at least. The great rivers of the Celestial empire give no trouble to its inhabitants; agriculture is said to be perfect; no one seems to have proposed to throw the refuse of Pekin into the nearest stream, that stream too, as it might happen to be, the source from which the inhabitants of the capital obtain the water required for their manufactures and for the arts of life.56

Civilization on the banks of the Thames is no doubt very different and very superior to what it possibly can be on the banks of the Yellow River, but as, *non omnia possumus*, as different races and nations, like individuals, have each their peculiar excellences and forms of civilization, excelling in some, deficient in other qualities of mind and body, it may undoubtedly happen that even the

English of the present day, the most perfectly civilized nation on the earth, or that ever lived, might take a hint from some other nations on points respecting which their otherwise inimitable genius seems to show some slight deficiencies. As regards art, for example, we owe some hints to the pitiful States of ancient Athens and Corinth; the despicable Copt had connected the Mediterranean and Red Sea by a canal—the art of re-opening which seems now to be lost; even the miserable native Peruvian and Mexican had carried the arts of mining, of irrigation, and the use of artificial manures, to an extent which surprises the men of modern times, who, in Britain at least, think that civilization really only appeared in the world during the reign of Queen Anne, as in France the era of the Grand Monarque is universally admitted to be the period when the French nation first threw off its primitive barbarous and Celtic form of civilization, assuming the character and social habits of that race to whom they owe their name, though not their descent. If we cast our eyes over the surface of the earth, aided by the lights, somewhat obscure, no doubt, of history, certain facts rising above the ocean of detail appear as landmarks. The philosophic historian points to, as peculiarly within his province, the transfer of the seat of power from nation to nation, from race to race; how before Alexander appeared there seemed to have been a Sesostris; after the son of Philip came Julius the Dictator; then Napoleon; and drawing conclusions as to the future from the past, historians see no improbability, at least no impossibility, in New Zealand, after the lapse of many centuries, producing the Hume of the southern hemisphere; whilst a future capital arising in the desert regions of Siberia or Northern America, may one day dictate to the world.[57] Ever at variance as to the rise and fall of empires, they are yet agreed as to certain facts and circumstances, many of which are still verifiable by the geographical distribution of the existing rivers and mountain regions of the globe; and even if man, in the plenitude of his scepticism, were disposed to doubt, monuments exist, the undeniable work of human hands, under circumstances implying the existence of a social system which cannot well be misunderstood. “In the boundless annals of time, man’s life and labours must equally be measured as a fleeting moment;” but the Pyramids, and ruins of Karnac survive the Kaliffs and Cæsars, the Ptolemies and Pharaohs, and countless monarchs and dynasties prior even to them. Thus, whatever learned disputants may imagine as to the primitive occupation of the valley of the Nile, the date of its occupancy, and the race by whom it was first cultivated, we have in the Pyramids incontestable proofs of a vast antiquity. Whatever historians may say of the antiquity of ancient Rome, the *Cloaca Maxima* of Servius alone refutes the beautiful romance of Virgil—how Lavinius and Turnus received Æneas ere Rome was; how Romulus and Remus founded Rome, and were

succeeded by seven kings, none of whom ever in reality existed. But the existence of the *Cloaca Maxima* and the researches of the illustrious Niebuhr tell another tale more consonant with what we know of man's social and physical nature. In the most remote times, man early adopted those measures of self-preservation which nature or simple observation teaches him. History gives but little information as to the measures adopted by ancient nations to secure public health; and were it not for the remains of the *Cloaca Maxima*, so called, of Servius Tullius, we should be as ignorant as Virgil assuredly was of the ancient condition of Rome prior to the reign of the seven fabulous kings.[58] Unquestionably the ancient race which preceded those grand Romans who fill the page of history for nearly twenty centuries, had discovered such means, and adopted measures for the safety of the people. Authentic history, it is true, commenced with the Greeks and Romans, and the history of Germany dates from Cæsar and Tacitus; but the subjugation of the double-horned Rhine[59] must have commenced long before "the building of the city."[60] But the world as known to the Romans, even during the reign of Trajan, was a contracted world compared to what it is now. The tropical regions of the East, and their vast populations, were wholly unknown to them; of Africa they knew but little, of Asia still less, whilst the New World was as if it existed not. Thus certain great problems in the history of mankind were never presented to them, problems having a basis in facts which men, for obvious reasons, are so unwilling to admit. The periplus of the Mediterranean might almost be said to form the Roman world; beyond the Rhine they made no conquests; the Danube formed their north-eastern boundary; the eastern shores of the Black Sea were but rarely visited by them; beyond the Euphrates and Tigris they, the Romans, never gained a footing, whilst from tropical Africa they were entirely excluded. Thus at no time were they called on to solve the problem as to the possibility of European life maintaining its ground in tropical regions; at no period were they called upon to give an opinion on the momentous question which now agitates the world, the admission, namely, of the primitive coloured races of men into the bosom of civilized society.[61] "Wheresoever the Roman conquered, he inhabits;" a just observation we owe to Seneca, confirmed by the history of that wonderful people. As their conquests were confined to countries in which the natives of Italy could at that time live and thrive, the rapid extension of their empire, language, and forms of civilization, need not be wondered at. Thus Rome successively became mistress of many nations and races, but these were races with whom the Romans could freely amalgamate; at no period of her history were they called on to contend with the two great questions, the one social the other physical, involved in the attempt to occupy by a white race a tropical

country, and a land inhabited by a purely savage race of coloured men; the problems presented by modern history of a European race attempting to hold India by the sword, to colonize the American world from the Polar Sea to the Land of Fire, to inhabit, if not to cultivate, the insalubrious Antilles, the banks of the Oronoco, or of the still more dreadful Senegal, Gambia, and Niger, nowhere occur in Roman or Grecian history; so that these are problems towards the solution of which ancient history offers no assistance.

A historian whose works I have already quoted on several occasions, and who of all men had perhaps with most profit studied human nature, has remarked that the aspiring genius of Rome sacrificed vanity to ambition, deeming it more prudent to adopt virtue and merit for her own wheresoever they were found, among slaves or strangers, enemies or barbarians. This sacrifice it was easy for the Italian race to make; naturally swarthy, and not unfrequently olive-coloured, they met with no race with whom the Romans might not freely amalgamate. Far different is it with modern Europe and her races; follow them to tropical India, Africa, and America, and it will be seen that extinction seems the sure result of all their efforts, whether they unite with the native races or not. If they unite, their purer blood, as we may so call it, soon disappears in the stream of a darker population; if they spurn the union, climate, or as some would term it, malaria, speedily exterminates their race and name.

In the first or second chapter of this Essay I ventured to suggest that the discovery of the art to modify the earth, air, and waters of all countries, so as to render them habitable for *all mankind*, was the grand problem man is now called on to solve. In the construction of the continents of the globe, nature seems to have had in view the formation by centres of life of the living inhabitants of the globe. In these centres she placed forms of life equal to sustain their existence, occasionally aided, at other times unaided, by human industry. In the virgin forests of America the aborigines lived and throve; under their hands the earth underwent no modification; to the negro the deadly regions of Central Africa are healthful and pleasant, though at times abandoned to nature, at times deeply modified by human industry. India and Java, the Malayan peninsula, as well as ancient Mexico and China, were many of them highly cultivated regions, in which the aborigines multiplied and enjoyed life; to the European they are premature graves.

But when it is attempted to transfer these centres of life to other regions, the attempt has uniformly failed.

And yet the Romans, admitting that they never encountered a tropical climate, seem to have colonized and thriven in countries in which the natives of Western Europe cannot now maintain their ground, cannot keep an army effective in the field for any length of time. The Roman legions and citizens occupied the country of Numidia without an effort; modern France, with an army larger than Rome ever had, can scarcely maintain its position in Algeria. The young population are cut off in their infancy, and it would seem that to maintain a Celtic race in Algeria will test the energies of an empire which it is true formed but a small province of imperial Rome. When we contrast late history with the diffusion of Rome's armies and citizens over the then known world, we are forced to the conclusion, either that the Italian constitutions of those days were stronger than those of the present inhabitants of Europe, or that the form of civilization presented more safeguards for the protection of health and life.

Nothing like the disasters of Varna and the Crimea seems ever to have overtaken the Roman legions who guarded in the time of Trajan the mouths of the Danube and the coasts of the Euxine, or restrained and kept in check the barbarous Moors.

Amongst the arts practised by the ancients, but now lost, we must include, I think, the knowledge of that discipline and practical skill by which the Roman, Greek, and even Tartar generals, contrived to keep their armies in the field in health and efficiency, whether storming the castles of Jugurtha, or building walls of defence in that land where English and French troops can neither fight nor march.62 Amongst the lost arts, still known it would seem to the Chinese, is that of rendering salubrious the site of vast cities and camps. If I am right in the principles I have endeavoured to establish throughout this Essay, this art must have been based on the practical knowledge that, generally speaking, the earth, as framed by nature, is not usually an unhealthy *habitat* for those races which grow up in her centres of created life, and it is only when man interferes, and interferes imperfectly, that the air and waters become pestilential to him. The secret lies, no doubt, in agriculture, that first of human arts—that art by which civilization exists. That human life is of as much value by the banks of the Meuse, the Scheldt, and the Rhine, as in Sussex or Surrey, is due to the industry of the inhabitants of Brabant and the islands of the Rhine. On man in a great measure depends the position which life is to hold in the scale of fate; he may raise it to its maximum or sink it to zero. Centuries, it is true, may elapse before human industry can render the banks of the Senegal, the Maranon, or the Zambeze, a fit abode for civilized European man, but if the European persist in

transporting himself to these haunts, he must discover the means to do so in safety, or perish in the attempt. Nature did not make these countries for him, but she gave him reason, judgment, observation, and the power of generalization, on the right use of which faculties his safety must ever depend. The celebrated Jefferson apologizes in one his confidential dispatches to his government for noticing various political movements in countries seemingly remote from and devoid of all interest to a citizen of the United States of America, by remarking, that although such matters seem remote and foreign to the object of his duties, they may yet at no distant period swell into relations of sufficient magnitude to shake the world. As in the political, so in the moral world; whether the empire of the Sultans stand or fall, may be a matter of little import to an inhabitant of Western Europe, nor need it distress him that the finest countries in the world are nearly reduced to deserts under the administration of the odious Turcoman. But it may be useful to him to be on his guard as to the condition of countries through which the spirit of commerce now urges the Western nations. Many of these countries do not improve; to compare them with what they were in the days of Trajan were merely a mockery; the low lands of the delta of the Danube are simply foci of fever and pestilence, and are likely to continue so under their present government.

All history points to the East and to Africa as the seat and source of plague, and the entanglement of Eastern affairs presses more and more on the European nations; if we may trust the statistics of commerce, Western Europe at times draws a large portion of her subsistence from countries of which we know but little. On this I make no remark, my object being merely to show that, however distant these lands lie, their malarious condition has an influence over the European family of nations, an influence which daily increases socially, and which, though originating in the obscure and unknown East, has shown itself at times at Rome and Moscow, London and Paris, in characters compared to which all other evils appear insignificant.

All that lives or has lived is doomed to die, to waste away, and to disappear; as it perishes it is consumed by nature’s processes, in such a manner as to entail no danger to the living world, unless civilized man interferes. For civilized man she has made no provision, saving the bestowing on him a soil more or less fertile, a constitution more or less equal to toil, a reasoning power, which in things practical must not be measured by the loftiness of his conceptions and generalizations.

Whenever and wheresoever he congregates into masses, there “the earth, the air

Whenever and wheresoever he congregates into masses, there "the earth, the air, and the waters," receive modifications from him, which, when injurious, he alone can rectify. The most consolatory view which man can take of such a condition of things is unquestionably to believe them to a great extent remediable by his own labour and intelligence; for even should he fail, there remains to him the consolation that he has done his best.

CONCLUDING CHAPTER. AUTHOR'S THEORY OF MALARIA.

It is easier to pull down than to build up; easier to refute than to convince; easier to find fault than to suggest a remedy: and this reflection may occur, and no doubt has occurred, to those, be they few or many, who have perused the preceding chapters of this work. It may now be asked of me explicitly, What is your theory? What is your remedy for the evils complained of? To this I might reply, as the immortal historian of the "Decline and Fall" is said to have done, "If you have read certain chapters of my work with sufficient attention, you may extract from them my meaning and my views;" but as this might imply on my part either a Teutonic love for obscurity in phraseology, or a fear to commit myself to any theory, I shall here sum up in a few words the views I have arrived at after much reflection on the matter, during a long and active life passed in a country supposed to be a hotbed of malaria, the great source indeed of malaria in Western Europe, that land for which nature has done so little and man so much.

1. There floats in the lower strata of the atmosphere in all regions of the earth, but in very various proportions, for reasons already explained, a poison or poisons, generated by the processes which nature adopts for the destruction of past generations, and the reconstruction of those to come; the destruction of the aged, the worn-out, the nearly extinguished; the reconstruction of the organisms springing into life, to occupy the place of those that were! Whether the poison be one or many; whether it be a single species or one of a natural family, does not affect the general conclusions. The diversity of its effects is no proof of diversity in its essential nature or even origin; the living principle is supposed to be of one nature everywhere and for ever; yet see how varied are the results of this principle in moulding the vegetable and animal worlds; how slight are the modifications even in organic elements, which, when called into play, give rise to the most astonishing and unexpected diversity of results. Why should it not happen, then, with the poison, influence, or thing we call malaria, which, modified by a chemical action too subtle for the scientific man to observe, may yet, being so modified, give rise to an intermittent or a remittent, a plague, a cholera, a diphtherite, a scarlatina, a typhus, or a small-pox? Where did so many poisons come from? Whence came the murrains, the vine-plague, the potato-destroying poison, which was not at all new, neither was it confined to the potato? Whence came the pestilences which destroyed the ancient world? which

exterminated at once whole species and genera now extinct? Of one thing we may be assured, they did not die a natural death.

2. This poison, whatever it may be, floats in the lower regions of the atmosphere, supported therein by the gaseous products of fermentation, and more especially by the ammonia now proved to exist everywhere in the atmosphere. It is the product, in fact, of the slow combustion perpetually going on in the air, the earth, the waters, wherever, in fact, animal or vegetable organisms are to be decomposed. We call it putrefaction; it is in truth a *ferment*, and the fermentable matter, that which gives rise to the ferment, is the immediate agent as well as the result (for it is the nature of all ferments to reproduce their process) of this fermentation, accumulated in the lower regions of the atmosphere. Increased to the dangerous point by men's imprudence or ignorance, quickened by epidemic influences with whose nature we are of course wholly unacquainted, and absorbed by the living tissues, it excites that fermentation, that tendency to putrescence in the living blood to whose results medical men have given so many appellations. At times it is called ague; at times remittent fever; now it is small-pox; and now a fatal diphtherite. To the transit of *ferments* through the air and to their inhalation by man, I ascribe the diseases usually called zymotic. In ancient primitive times, when physicians were rare,[63] and men did not interfere, a poison thus absorbed ran its course from incubation to specific fermentation, with all its results, in a given time, terminating in a crisis which might be calculated and determined; and which might prove fatal or at once remove the disease. A violent perspiration, a severe diarrhœa, a specific and contagious eruption on the surface of the body, proved and effected the elimination of the poison from the system. The ferment had done its work; it had altered the mass of the blood, and the products of the slow combustion (*putrescence*, rottenness, *fermentation*) were discharged by the secretions, according to circumstances peculiar to the constitution of the individual: as out of the same materials serpents elaborate poisons of very different powers and qualities, so the *ferment*, passing through various constitutions, gives rise to various results. It pervades the air and clings to it, nor can it be avoided but by a change of place of residence;[64] storms may, and no doubt do, affect it, but they frequently fail in dislodging the poison; intervening wide-spread oceans fail to interrupt its course;[65] and as regards the caprice exhibited in its attacks, we have only to reflect on the number of elements, vital, atmospheric, social, and chemical, involved in its full maturescence. Our doubts on all such matters originate probably in the coarse chemical theories and still coarser chemical experiments which prevailed about thirty years ago, and from their influence, from which

men’s minds have not as yet escaped. The atmosphere was declared to contain a few wide-spread gaseous elements, and to be unalterable; the air of towns, of theatres, of large heated apartments, crowded with people, was boldly asserted by chemists still alive to be eudiometrically perfect.

§ 1. *Discovery of foreign bodies, the remains of animal and vegetable life, and therefore* FERMENTABLE, *in the air floating over canals, ditches, marshes, &c.*—Scientific chemists, as well as the professors of the conjectural art, are occasionally behind the knowledge of the careful, observing, unprejudiced practical men of the day.66 Experience taught me, whilst engaged in other inquiries, that the sulphuretted hydrogen gas arising from the waters of the canals of Holland is quite sufficient to spoil cottons printed with nitrate of lead, used for dyeing yellow with the chromate of potass. The waters of these canals hold this gas in solution in a certain sense, but from May to September inclusive, the gas escapes during the night in great abundance.

At this time vapours arising from the waters and floating over the adjoining grounds, were found to contain minute portions of aquatic plants mingled with the spores of fungi in vast abundance, together with fragments of a membranous and gelatinous substance about to be mentioned. To these must be added the remains of infusoria not to be detected in dried specimens.

The injurious effects of water holding such substances, gaseous and solid, in solution, we overcome by boiling and passing the steam through (heated) iron pipes, and re-converting the steam into water. By this process we get rid of the injurious effects of these foreign matters, gaseous and solid, held in a kind of solution by the water, in as far, at least, as they affect the colours used in dyeing.

During these examinations of the waters themselves, it was distinctly observed that the infusoria and testaceous mollusca, microscopic and otherwise, with which such waters abound, were developed in glutinous membranes attached to the aquatic herbs abounding in these waters; in short, these membranes seem to be the matrix for the growth, nourishment, and production (using the term in a limited sense) of these organized beings; they form an essential condition of their existence.

The plants themselves were now washed in distilled water, and the animal products were the semivalve and bivalve shells of which I have preserved many specimens. The semivalve belong to the natural families Buccinum, Lynceus, Helix. and Planorbis: the bivalve to the Cardiacæ. The semivalves are the most

abundant. By filtering the water which remained after the shells had been removed, innumerable minute particles like dust were discovered; these particles were ascertained by the aid of the microscope to be mainly composed of minute fragments of aquatic plants and of the spores of fungi; to these must, no doubt, be added, although not visible when dried, the remains of zoophytes, and of the glutinous membranes forming the matrix of animal aquatic life.

I now endeavoured to obtain the glutinous membrane or matrix in which these testaceous mollusca were obviously developed, apart and distinct from the animals themselves. To attain this desirable point we filled a glass receiver with water containing the aquatic plants and shells, and the gelatinous membrane already spoken of. The receiver was now inverted upon a plate, and water poured into the plate to the depth of half an inch.

In a few days the receiver became filled with gas, forcing the water downwards into the plate on which the receiver rested; and although after the first day we could not discover any of the gelatinous membranes in the lower part of the receiver, yet that in the plate became like a flaky jelly, attaching itself to blades of grass or leaves. The surface exposed to the atmosphere became dry and brittle, and in this state resembled thin layers of gum; the substance thus desiccated strongly resembled jelly.

The glutinous membrane of which frequent mention has been made above, is of a very viscid nature, and when combined with any animal substance in a state of transition or fermentation, it is poisonous. It is, I believe, generally viewed as the matrix for the development of the ova of these shell fish, and considered as a product or secretion of the parent. Into this question I enter not, leaving it, if it be one, to others.

On exposing for a few days some of the larger testaceous mollusca alive to the atmosphere of the room at a temperature varying from 65° to 70° Fahr., strong proofs were obtained that ammonia was produced in the interior of the shell confined therein by the membrane called operculum, sealing, as it were, the aperture into the shell hermetically. On puncturing this membrane the presence of ammoniacal gas could be distinctly traced by the odour.

I submit to the consideration of professed physiologists the following questions:—1st. What are the effects likely to result to man from the inhalation of these microscopic and gaseous products in a state of decomposition, they being

certainly present in the vapours arising from the waters of canals, ditches, &c., in many countries, especially during the nights of spring, summer, and autumn? 2nd. What are the evil effects likely to arise to man from the use of such waters as drink, or when employed for culinary purposes? Lastly: As the gelatinous membranes alluded to are the nidus of various forms of organic life, and contain those forms, developed and undeveloped, occasionally in a state of decomposition, to which of the two forms of life, animal or vegetable, or to both, is to be ascribed the deleterious effects on man, and ascribed by physicians to an unknown poison called Malaria, designated by them as “a poison, an influence, a miasm, a thing unknown”? Ferments and putrescence are not “things unknown:” let us adhere to facts.

§ 2. Thus the principle of wasting away by the action of the atmosphere, of the rotting of vegetable and animal substances, first developed by the illustrious Liebig, opened up to me the path to that theory which seems to reconcile the conflicting observations of pathologists,—that vegetable and animal matters do ferment or rot, and that in this state of rottenness they are carried through the air, was with me no longer a matter of doubt; next came the question, as to the effects of such matters on man when inhaled by respiration and conveyed directly into the living, circulating blood, that most complex of all fluids, that mysterious compound out of which nature constructs the animal world.

This slow wasting takes place in any damp place under ground, and the ferments assume the form of vapour when such places happen to be warmer than the open air; it is in this state that the odour is so sensible to us after a hot dry day or during cold nights. There is no smell in rainy or damp weather. It is in the spring and autumn months when ferments from slow combustion abound, aided by the amount of heat and moisture which then prevail, and by the floating of plants. The poison thus generated is known to be the product of a ferment, and like many such products, possesses the quality of fermenting other organic compounds with which it may come in contact. Introduced into the living system of man, it finds in certain individuals the material already disposed to pass into fermentation. It incubates, and this incubation is measured as to time by a variety of circumstances I need not enumerate. In cold countries the incubation is slow, extending over many months; not that the ferment differs, but its action is modified by the existing condition of the accessories to its action and power. The ferment introduced into the blood in autumn may not show its full action on the living fluids until the following spring, or early in summer: in hot countries it is different; there the ferment, aided by numerous adjuncts, acts almost

immediately; fever sets in, causing violent reaction of the conservative powers of nature; delirium, coma, vomiting, death. The mass of the blood has undergone a change in all its constituents, and dissolution and putrefaction are swift in reducing the frame, even whilst life is still present, to that state to which all that lives must come at last; whilst the physician loses himself in vague theories of an "unknown poison"—a malaria, a something not strictly a gas, a matter or influence differing from all chemical or other agents known, the scientific chemist steps in, and shows that the subtle matter they so anxiously endeavour to discover, is a process constantly going on before their eyes; a chemical process, universal; the process, in short, on which in a great measure depends the disposal of the dead and effete remains of the organic world; the growth, the nourishment, the renovator of each successive generation of the same world.

§ 3. It may be now fully admitted that ammonia is the active principle or stimulus to vegetable life, as shown by the extraordinary growth of plants in warm damp climates; in these malaria—as we may still call the poison so developed—exists to the greatest extent, as in the Pontine Marshes, by the banks of the Po, Ferrara and Bologna. From various experiments and observations, I have been led to the conclusion that the ammonia constantly present in the atmosphere, and derived from several sources,[67] is the chief cause of the activity which the ferment, or poison, displays under different and varying circumstances. There prevails, in truth, an excess of ammonia in such an atmosphere, resulting from the nitrogen uniting with hydrogen; from the decomposition of vegetable matter carrying decayed animal matter along with it; and from the ammonia always existing in the spawn and in the matter of the shells of infusoria. All my researches into the effects which the various gases have upon animal tissues, showed ammonia to be the most destructive; in fact, no animal tissue can resist complete decomposition by caustic ammonia. I conclude, therefore, that vegetable and animal matter in a state of fermentation, and mixed with ammonia, is the cause or essence of that destructive power which physicians ascribe to malaria. Should this fermentable matter pass in a concentrated state into the torrent of the circulation, the globules of the blood are destroyed, and become black; the person is in the cold stage of fever; next, the vegetable matter ferments, causing the hot stage. No one in Holland has any doubt as to the origin of this power, but ascribes it uniformly to the draining of some lake; and it amounts almost to a demonstration that the air under such circumstances is poisonous or injurious to health. It was even foretold by several writers that fevers would result from draining the lake of Haarlem, as took place in the years 1608, 1641, 1727, 1779, from draining various polders.[68]

If the principles I have announced be correct, the extreme impropriety—not to use a stronger phrase—of carrying on excavations or other extensive works on the muddy banks of rivers, in marshy or swampy forests, during the summer months, must be obvious to all reflecting persons. No work should be done in such places, or in ponds, after the month of April, for it is warm dry weather that sets malaria afloat. But if this ferment—which we may strictly call malaria, as producing a malarious condition of the air—be, as I apprehend it is, the cause of fever, why should not medical men direct their attention more earnestly to the question in how far such a fermentation of the blood may be met by the employment of substances known to resist and counteract fermentation? Are physicians agreed on the nature of fevers, and the best means of curing them?69

Nothing can be more interesting, in a natural history point of view, than to watch the results upon large bodies of water, of attempts, more or less successful, to complete their drainage. Thus during the operations carried on for this purpose at Haarlem, there sprung up in the dry places of the more elevated parts an extraordinary quantity of plants and herbs, which were not seen in the country before they flowered and sent millions of seeds with their diminutive rocket, silky tails into the air. They were too minute to be seen upon grass, but the footpaths were covered with them, and a current of wind might carry them to distant regions, as the sand is carried from the coast of Africa into the track of the Brazilian packets, to such an extent as to make it uncomfortable to walk on deck. It is by no means, therefore, improbable that those errant seeds came from a foreign land, the native produce of other countries. Continuing my observations into the transit of seeds, I have found them to be the cause of shallow canals in England being full of heretofore unknown water-plants, to the extent of impeding navigation.

It is mentioned in the “Kosmos” of Humboldt, that the dust resulting from eruptions of the volcanic mountains in South America was observed in Spain. But if currents of wind thus carry seeds and other matters hundreds of miles through the air, no one can be surprised that the aquatic plants above alluded to floated to England through the air, from Holland; these plants, new to the land of their accidental adoption, bring with them a new corresponding animal life; in due time they come to maturity and die, and now Nature steps in to take up the task, and complete her work; her process is simple in appearance, most complex in its results: a malarious air—malarious at least to man—appears, as it may be, for the first time in the district, ascribed by medical men to every cause but the true one. In their anxiety to discover a cause, they fix on some antiquated drain,

or cesspool, or ditch, by the margins of which many generations of a stout peasantry had lived and died; or they dive into the pump-well, and triumphantly exhibit infusoria, not unlikely engaged at the very moment in purifying the water: it never seems to have occurred to them that *ferments* only appear in certain combinations of the air—under circumstances which only occasionally occur, and that (which is most lamentable to think of, as in the case of London and the Thames) the evil is most frequently of man's creation.[70]

The operations of nature when left to herself never vary; they may always be calculated on, foretold, anticipated; on this assured and irrefutable fact all science rests. It is only when man interferes and modifies the elements at work that nature seems to alter her processes; a disturbing agent has been thrust into the machinery, and the mischief it effects must either be counteracted or entirely overcome. So long as the Lake of Haarlem was a lake, or mere, so long were its banks healthy; but drain it partially, and you must be prepared for the result. There is no middle course; that which was once a lake or sea cannot be left in the condition of a putrid, imperfectly-drained, fermenting mass of mud, teeming with animal and vegetable life, and with a material for which oxygen is the natural ferment; it must be arrested by the hands which drained, or attempted to drain it, and converted into a healthy pasture-land or a wheat-field; if left to nature, centuries might elapse before that which was once a sea would become a healthy forest or natural meadow, during which period man, should he persist in residing on its banks, must undergo the penalty of his own want of knowledge.[71]

CONCLUSION.

In the first chapters of this work I have endeavoured to trace briefly yet succinctly the history of opinion as to the nature of malaria, showing how, prior to the appearance of Macculloch, no one had given to the theory of malaria any definite form. In those which followed I have traced the history of his presumed discovery from the period of its first announcement to its distinct refutation by one of the ablest of statisticians, showing that, notwithstanding this refutation, the physician having, in fact, no other theory to fall back on, persisted in adopting the theory, and, as a natural result, continued to look for and to find in cesspools and ditches, lay-stalls and drains, that unknown and mysterious poison which they had been told by Macculloch was the cause of all diseases. Confounding it with bad odours of all sorts, they sought for remedies in the destruction of bad odours; at times they sealed the sewers and cesspools

hermetically and by law: now they opened up and ventilated the sewers and cesspools also by law;72 and lastly, on finding that they had poisoned the air of the metropolis, and that every experiment they made ended in the precisely opposite results to what they had foretold would happen, as a last resource they endeavour now so to dilute the refuse of living beings as to render it, if possible, inodorous at least. This experiment will also fail. Like true Englishmen, they would not let well alone; they would attempt to solve questions by main force, which science, aided by long and careful experience and observation, could alone effect. At last Liebig appeared, and gave to the whole question a new phasis and another basis; that basis rests on an appeal to the great laws of nature, and not on any researches into the occult, hidden, and mysterious laws regulating the building up and the constructing of the various forms of animal and vegetable life. In this grand work the vital force is in action, whereas the destructive processes by which she annihilates her own forms are strictly chemical; there science may be properly said to commence in respect of the great question I now consider; and uniting experience with observation, it seems to lead to the following conclusions, which, if legitimate, will probably stand their ground until overthrown or modified by the larger experience of succeeding ages.

§ 1. Seeing that *putrescent*, that is *fermentable*, bodies can and do exert so great an influence on organic compounds when dead (in the sense we consider them), it is not unreasonable to suppose that animal structures and fluids capable of being fermented, may undergo the same process, that is, fermentation, putrescence, and destruction, or decay, whilst forming a part of the living body.

§ 2. As no sane person doubts the harmony which can be shown to exist in all created beings, so it is probable, if not quite certain, that the laws of decomposition must be as regular as the laws of composition; or, in other words, that as the organic matter is without a doubt the same throughout the living world, and as living bodies are built up or constructed agreeably to certain laws, so, undoubtedly, will they be decomposed by laws equally fixed and constant; invariable; and the nature of the material so decomposed will in no shape be affected by those specific differences which bestow on organic nature her beauteous and varied aspect.

§ 3. The final product, whether of composition or decomposition, must be the same in all respectively; the infusoria, as well as the gigantic whale and elephant, are composed, when living, of the same elementary tissues, and, when dead, decompose into elements the same in all

dead, decompose into elements the same in all.

§ 4. The presence of microscopic animalcules in putrifying substances is viewed by Liebig as accidental, and not essential to putrefaction or to fermentation; but even admitting this, it is certain that animalcules (infusoria) exist everywhere in inconceivable numbers; if water contains these putrescible substances, as it must always do, then the infusoria are also present in the water; let this water evaporate under the heat of the sun, and we have in a fermentable, that is, putrescible, condition countless myriads of infusoria wafted through the atmosphere, and in certain localities (Pontine Marshes, Sierra Leone, the Orinoco, &c.) forming almost a constant, if not a constituent, part of the atmosphere; they pass into living bodies by respiration: hence the hitherto inexplicable phenomena with regard to the influence of locality in the production of disease, whether derived from animal or vegetable remains.

§ 5. Thus these bodies cause disease, not as live matter, but as dead, fermentable, and putrescible. They are not found everywhere, nor are they everywhere liable to pass into fermentation, a certain degree of heat being necessary for the production of this condition. Their evil effects on human life are chiefly felt when man places himself in a false position in regard to them. In pursuit of gain, national or individual, he seeks the deltas of the rivers of hot climates, plunges within the tropics, despising the maxims of the natives of those countries, encamps on or near putrescent marshes, hoping to escape destruction; prances in holiday costume across the Dobrudscha, as if he were on the Champs Elysées or the grassy slopes of Hyde Park, and having carried folly and contempt for the experience of others to its height, pays the sad penalty sure to be exacted by nature from all those who despise her warnings.

These are my opinions, supported, I believe, by facts and figures, and to those who honour me with a perusal of the preceding chapters I beg leave to say, in the words of the ancient poet and satirist—

Si quid novisti rectius istis,
Candidus imperti, si non—his utere mecum.

APPENDIX.

To avoid overloading the text, I have thrown into the form of an Appendix several Notes more or less intimately connected with the great question considered in the body of the work. They may be read with or without any reference to the various headings they treat of.

Note 1.

By the deodorizing processes now in use, the ammonia, the most valuable constituent of manures, is destroyed; whilst by the flushing of sewers with an excessive quantity of water it is dissipated; hence the low value, or rather the absolute inutility of the sewage of large towns, as manure, when diluted with the surface drainage and other waters, excepting in the case of reclaiming waste lands, in order to convert them into meadows of so highly objectionable a character that no one can or will reside near them. The smell from such meadows is most abominable.

Even in such cases an outfall must be provided for the surplus sewage waters, either into a river or into the sea, for the meadows to be irrigated require but little of it, and that only occasionally and during droughts.

The fixing the ammonia is the great difficulty the agriculturist experiences in all questions respecting those manures which naturally contain or produce it. Its volatility is so great that it not only readily escapes into the air, but carries along with it, especially from waters, bodies at the moment in a state of slow combustion; or, in other words, ferments, capable of exciting fermentation in other fermentable bodies.

It may even pass into the condition of caustic ammonia.73

In a well written pamphlet by Mr. Ward,74 the unhappy and fatal mistake of mixing the surface drainage with the sewage of London is clearly pointed out for the hundredth time, but the parties who planned the scheme will no more take notice of such facts than they did fifteen or twenty years ago, when they commenced their work of polluting the Thames and other rivers.

To Mr. Ward's proposal of purifying the river and fertilizing the land by tubular

To Mr. Ward's proposal of purifying the river and fertilizing the land by tubular drainage, there are, however, many serious objections.

Note 2.—*Habits of the* WILDE*, in desert or uninhabited countries.*

It is known to sportsmen that in the neighbourhood of hills, partridges leave the low grounds at the approach of evening, and take themselves to the hilly or more elevated district. Nature has taught them a very curious fact in meteorology, namely, that on leaving the valley at night, and ascending the hill, the temperature of the air increases up to a certain elevation, and from that point upwards decreases. The game ascends to the point of highest temperature, and there remains for the evening. A friend informs me that whilst crossing the high range of mountains forming the watershed between the Grotevisch Rivière and the Zondag Rivière, in Southern Africa, he experienced as he ascended intense cold, with heavy dews in the valleys through which ran the sources of the Grotevisch Rivière, and these continued until he reached the base of the crowning heights. Here the party slept in a mud-hut belonging to a Dutch boer. During the ascent they saw no game; but on climbing about half way up the remaining steep before daybreak next morning, they reached a spot where all the large game had congregated. It was the point of greatest warmth, generally a few hundred feet above the plain, and below the summit of the mountain. From this point to the summit the cold was most intense, and snow lay on the high peaks of the mountains.

When the shells of infusoria are driven about in the atmosphere they lose their carbonate of lime by the acid fermentation; and the membranous portions having the properties of coagulated albumen, and being also fermentable, may, by passing into the blood, become excitants of fermentation. This has been already fully explained in the text.75

Note 3.—*Moss.*

In the *Annales de Chimie*, volume xxix. p. 225, mention is made that the walls of various towns which had been under water for several years having become exposed, from the effects of a dry summer and hot weather, became covered with vegetable matter, the decomposition of which infected the atmosphere, and caused great sickness in the environs, and particularly where buildings were situated in marshes in communication with the sea. The vegetation, in fact, was composed of lichens.

On a recent visit to Bangor, in North Wales, I was struck with the nice firm turf which was in the garden; and upon inquiring of the gardener, he informed me that the turf came from the seeds blown from the hills, and that it required great care on the part of the farmers to keep it under, or it would be exceedingly injurious to land and buildings if neglected. When it grows on walls it splits them by the capillary expansion of its roots between the bricks operated upon by damp hot weather. I have seen this lichen destroy the pillars of a gateway three feet thick.

Mill-stones are made in Germany out of granite, by means of willow pegs being driven into holes thinly covered with water; this causes the willow to act by capillary expansion, forcing the mill-stones of the required size out of the rock.

It is of the utmost importance that the nature of moss and lichen generally should be well studied before constructing sewers, &c., where vegetable matter exists near water.

Was it by similar means that the ancient Egyptians and inhabitants of Arabia Petræa cut from the solid rock those vast blocks, in effecting which they do not seem to have availed themselves of any modern mechanical contrivances?

The *ferment*, that is, the substances in a state of fermentation and capable of acting on all fermentable bodies, and especially on complex organic compounds, as the blood, exist at all times in the air, but are as a matter of course greatly influenced by a variety of circumstances as regards their effects on man and other animals. It is proved by indubitable evidence that this morbific matter is as capable of entering the system when minute particles of it are diffused in the atmosphere as when it is directly introduced into the blood vessels by a wound. When diffused in the air, these noxious particles are conveyed into the system through the thin and delicate walls of the air-vesicles of the lungs in the act of respiration. The mode in which the air-vesicles are formed and disposed is such as to give to the human lungs an almost incredible extent of absorbing surface, while at every point of this surface there is a vascular tube ready to receive any substance imbibed by it and to carry it at once into the current of the circulation. Thus in certain seasons boils and carbuncles prevail to an alarming extent, and surgeons dare not operate lest they should lose their patients from erysipelas and inflammations, running rapidly into putrescence. In large hospitals the poisonous air in all probability is constantly present, attacking those who have been previously weakened by disease or wounds, or loss of blood; in other words, all

those in whom from any circumstance (as by the depression of the vital powers) the complex organic compounds are held loosely together, and are therefore prepared to ferment or to fall into putrescence.

Note 4.—*Anther.*

This name is given in botany to the summit or top of the stamen containing the fertilizing fruit-producing dust.

Pollen is the fecundating dust or fine substance, like flour, meal, or fine bran.

Farina, contained in the anther of flowers and plants, which is dispersed on their stigma for impregnation, form a vegetable essence constituting the particular nature of a substance forming the flower existing in other plants of the same family or kind.

Spore or sporule in botany is that product of flowerless plants which performs the function of seeds.

These substances float in the atmosphere, and are the cause of the hay fever; and when they fall into water and are afterwards left upon mud they ferment, and being dried up by the sun they fly about with the spawn of animals.

Should seeds fly about with the pollen or farina in a state of decay and full of carbonic acid, the oxygen of the atmosphere, so essential to human beings, is diminished, and the pollen or seeds are inhaled into the lungs, and are thus exposed to the action of oxygen whilst circulating with the blood.

The result of an excess of carbon in the air is the growth of ferns on barren rocks, which ferns subsequently become coal.

The same cause will always produce the same results. When vegetable matters rise from a large surface of earth or mud (as from the newly-drained forty thousand acres of the lake of Haarlem), there are no plants there to inhale the carbonic acid, and to give out oxygen; but those seeds being rotten or in a state of ferment, the oxygen for the decomposition is drawn from the atmosphere alone, and human beings who breathe this malaria have fever; the atmosphere is tainted: miasms of carbon with hydrogen gas (the lightest thing known) fly about, carrying them to points where sulphurous gases may find them a resting-place on mud and shallow waters: these give rise to fever, cholera, plague, and to

all zymotic diseases.

Note 5.—*Algæ, or Sea-weeds of the Mediterranean Sea.*

These were examined by Doctor Derbes, Professor of Sciences, and Captain Solier, of Marseilles, and the result of their researches was published in the supplement of the *Comtes Rendus* of the Académie des Sciences, in answer to a prize essay proposed by the Academy in 1847. Nothing can exceed the botanical truthfulness of the memoir presented by these gentlemen to the Academy. After a careful examination of the substances resulting from the mass of decayed sea-weed in the delta of the various rivers which flow into the Mediterranean Sea, they arrived at the conclusion that the product is the cause of fevers, by generating a malaria which the vital powers are unequal to meet. Thus the cholera existed at Marseilles in 1850; all knowledge of the extent of its destructive ravages was withheld from the public; and the truth of this is in some measure proved by the readiness with which the Board of Health recommend the quarantine of ten to fifteen days, when it was reported that the plague or cholera existed at Tripoli, Sicily, and Sardinia.—July, 1858.

Note 6.—*The Marseilles Board of Health and Quarantine.*

TO THE EDITOR OF THE "TIMES."

Challice.

Sir,—The Board of Health of Marseilles are about to establish quarantine regulations of ten days' and fifteen days' duration at that port, because "a dreadful plague rages at Bengazzi, in Tripoli, and is extending along the coast to Alexandria." Individuals are to be confined ten days, and in certain cases fifteen days. Letters are to be purified, &c., and some 1500 Piedmontese labourers are likely to be disturbed and thrown out of work if the proposed quarantine regulations are established. And so this is the sum total of sanitary experience for the last ten years! The French authorities saw all quarantine regulations broken down during the Crimean war; in fact, joined the British in abolishing a quarantine at Smyrna, at Galipoli, at Constantinople, at Sinope, at Samsoon, at Trebizonde, at Malta, and even at Marseilles, and indeed at all other ports and places used by the transports and by the armies in alliance.

The armies certainly did not escape fever and cholera in their most terrible forms. The French, the British, and the Sardinians alike suffered, both in the

field and in hospital, at the commencement. The British alone, however, by means of sanitary works and regulations, reduced cholera attacks to a *minimum*, and almost abolished fever. A few simple alterations to the sewers from the great hospitals on the Bosphorus and other places; ventilation—in many instances by simply breaking the top squares of windows; regular scavenging without and cleansing within the works of the hospitals, and the regular use of the lime-wash brush, emptied the hospital wards of fever patients. Surface cleansing at Balaklava, and regular scavenging both the shores and water of the harbour; covering the shallow graves with gravel and earth; scavenging the camp, and daily disinfecting all latrines, soon reduced the British army mortality below home or barrack life and service. The French neglected these things, or blundered in their execution, as the 5000 deaths per month in the hospitals on the Bosphorus, from hospital and camp fever alone, during the last three months of the war, testify. That certain diseases are contagious, such as scarlatina, measles, small-pox, &c., few will deny. That plague and cholera are equally contagious many doubt. Sanitary works and regulations of a very primitive and simple kind can certainly check the contagibility of cholera, as witness the experience in Newcastle-upon-Tyne and Tynemouth, in London, in many other English towns and districts, and in the British hospitals and camps throughout the Crimean campaign. The lesson taught by experience ought to be this:—Let the Board of Health at Marseilles cleanse the town, cause all the foul rooms to be ventilated and lime-washed, disinfect the foul cesspools and sewage, and cut it off by "interception" from the harbour and docks, and they may bid defiance to plague from any quarter. It may be imported in silks, &c., but it will not spread. Let there be a sanitary staff for the harbour, and another for the town, armed with brooms, barrows, and lime-wash brushes, in place of sidearms and muskets, and persons may land at once to go about their business, and merchandize may be forwarded to its destination without fear of consequences. During periods of epidemics there can be cholera without dirt; improper food and mental and bodily exhaustion may bring on isolated cases; but to have cholera rampant there must be numbers of human beings fouling air, earth, and water, and habitually living contrary to known sanitary laws and entirely neglecting sanitary precautions.

Civil Engineer.

August 14, 1858.

Note 7.—*Mud, Water, and Air.*

The presence of water and a suitable temperature are indispensable conditions of the oxidizing process of decay, just as they are necessary to putrefaction and fermentation. The sides of ponds and ditches being covered by water during the winter months, in the spring the air becoming warmer and drier, the water diminishes, the decay of vegetable seeds, plants, and all woody fibres enter now into putrefaction, communicating the process to each other, and by the transmission of decomposition from one particle to another, a great number of plants give out various gases to the atmosphere while decaying upon mud, rise into the air, meeting other gases, and then, floating about, they compose and decompose each other. Hence the bad odour from the mud-banks of the Thames, near the outfalls of the sewage.

Note 8.

I have known fevers cured by a change of the sleeping room from the south to the north aspect, and still more readily by removing from one side of the street to the other. All should avoid dwelling near canals, ponds, or ditches habitually covered with a white froth; this is formed, in fact, of gases rising through humus swimming on the water, and contains living beings as well as fermentable substances.

It is important to men who work and sleep in the same house to have the day or working-rooms to the north, where the sun never enters, and to sleep in a room to the east or south. A room to the west, looking to the west, is not healthy, particularly in summer months, being the hottest in the evening. Gnats, moths, and flies collect there, and are at least harassing, if not hurtful, particularly to infants.

No person not a native of a marshy country should travel overland in the evening; dew causes a strong action in vapours, mists, &c. Invalids and soldiers after fatigue, should halt in the daytime, and march in the evening, to avoid being chilled.

Note 9.

A sure remedy against the malaria of ditches, ponds, &c., is to fill the water-courses with water; never suffer them to be so far dried up that the spawn of living creatures may attach itself to the sides of grass, bushes, &c., and afterwards to dry and spread about like the seeds of flowers, in the environs. The mud which is left exposed to the air gives out, on drying, various gases, which

being mixed with the fossils of the mud, contaminate the air, and are breathed by the people in the neighbourhood.

A circular drain, having a double current, well understood by the hydraulic engineers of Holland, is the kind of drain I prefer.

THE END.

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FOOTNOTES:

1 Περι αερον, ὑδατων καὶ τοπων. Cary’s edition. Paris. 1806.

2 Medical authors of the highest repute are exceedingly vague in their ideas respecting the nature of malaria; nor will it ever be otherwise until the question be taken up by the strictly scientific. Thus, Sir John Forbes says, in his “Holiday:”—“As the unknown thing which we term malaria or miasma of marshes, under certain circumstances gives rise at one time to simple ague, at another to a fatal remittent fever, &c.; and produces at times a morbid enlargement of the spleen, at others diseases of the liver, &c.; so I can imagine that some other *malaria*, or unknown thing or influence of local origin, may be the cause of ordinary bronchocele, of goitre of the Alps, and also of cretinism.”

From the 1st of August to December the author hunted and waded through the marshes of Belgium and Holland in quest of water-fowl; his impunity from fever may be in part ascribed to a hardy training in early life.

3 Typhus, now subdivided into two—namely, the true typhus and typhoid fever.

4 Quetelet, “Sur l’Homme.”

5 The late Dr. Macculloch was a distinguished geologist in the employment of Government, representing in himself the department which has now swelled out into the Metropolitan School of Practical Geology, the Museum of Practical Geology, Jermyn-street, the geological department in connexion with the Ordnance, &c. &c. He resided mostly in London, and moved in the best circles. Though a strictly scientific man, he was a professor also of the conjectural art, having been educated as a medical man. Soon after publishing his first essays on malaria, thrown out as feelers to the profession and the public, he had his misgivings as to the safety of the course he was pursuing. To denounce open sewers, undrained streets, untrapped cesspools, and overflowing dead-wells, was

clearly an attack on the proprietors of London houses; and he called one morning in great haste on a distinguished barrister, to consult him as to the possibility of a passage in one of his essays being construed into a ground for an action for libel! How changed now are the views of society in respect of all such matters.

6 See the admirable speech of Mr. Disraeli in his place in Parliament, on the condition of the Thames.

7 It is right to observe that the unpleasant odour from the Thames, which during the month of June and part of July of the present year so disturbed the olfactory nerves of the Londoners, ceased at once so soon as the Bill for the purification of the Thames passed both Houses of Parliament. What connexion this had with the causes of the odour, and how these odours were so opportunely called forth and so quietly dismissed, I leave to be conjectured by the thoughtful of all classes. At this moment—August, 1858—during the most intense heat, the river is as sweet and fresh as a mountain stream, and has continued so ever since. Some are disposed to ascribe the cessation of the odours (for the stream is not in any way purified) to the throwing of quick-lime into the lower sections of the principal sewers; but if a remedy so simple as this was to be found in such a process, why was it not employed in June and July? It is only the unobserving who are surprised at such things, and who have not happened to observe what follows the spreading of an ancient cesspool over the fields by the road-side, or pouring its contents into a comparatively small river. The Thames is a comparatively small river, and the effects of pouring into it, at a convenient and suitable time (the dog-days, Parliament sitting, &c.), the contents of half-a-dozen cesspools of fifty years' standing, undiluted and at once, would most assuredly give rise to results such as took place in London in June and July. The plot was a very nasty one—it might easily have been traced and the plotters detected: the sewer-makers, under the direction, no doubt, of the various boards, were very active in various quarters; and, not to mention other places, the main street of Hackney, for instance, for nearly a whole day, was by such means rendered quite unbearable.

8 The Walcheren expedition.

9 Rapid changes in the barometric pressure of the atmosphere strongly affect some persons, but the *malaise* caused does not seem to be of a permanent character. In the spring, in Britain, when north-easterly winds prevail, the amount of skin disease, rheumatism, neuralgia, &c., is sufficiently remarkable, and the blights they cause in plants is a fact known to all. In a work published by

Mulder (“Water en Miht,” Amsterdam, p. 181), we find it mentioned that Van Swinden investigated the mutations of atmospheric pressure as a cause of sickness, and arrived at the conclusion that a low pressure was not the cause of sickness and fever. He remarked that although there had been many years in which much sickness prevailed, seemingly connected with hot and dry weather, the barometer had varied but little. Thus, at Haarlem, in the period between 1755 and 1780, the maximum was 30·9, the minimum or lowest, 28·0. The summer of 1779 was extremely hot, and a fever epidemic appeared which continued for three years. It was ascribed to the draining of several polders. Several learned societies made reports on the subject of this fever, but they elicited no new facts. It was generally agreed that the deeper the mud and turf containing vegetable matter were under water, the less was the sickness resulting from the draining. A Mynheer Driessen called public attention to the circumstance that on the coasts of Holland there were many places where animal and vegetable matter had accumulated and was in a state of rottenness or fermentation; and in this state he suggested that being carried inland by strong westerly winds, it might give rise to sickness. It is remarkable, however, that both the influenza and cholera progressed against the prevailing westerly winds.

10 Men in a state of nature seem to resist malaria. Thus the natives of Newfoundland and of Canada generally, and indeed of all America, withstood readily the malaria of their native land, but perished when brought within the influence of European domesticity. We must allow, however, for the power of race. On the other hand, it seems almost certain that the old Roman armies withstood the influence of climate much more effectually than modern armies do. They lived generally in camps, which they themselves fortified. Of their sanitary regulations we know nothing, but of their camps we know that no English or French soldiers could possibly stand their ground for any length of time similarly encamped. A legion (about 12,000 men) encamped on a space of 700 yards square; what became of the refuse of the camp, and how was it disposed of? No Crimean disasters ever happened to Cæsar; he could not afford to lose his veteran Legions as we lost the Guards.

11 Gibbon, vol. vii., p. 421, Milman’s edition.

12 The cholera, in so far as I know, has not as yet penetrated beyond the tropic into the southern hemisphere.

13 In the *Times* of to-day (September 8th), the contagious character of the plague

is stoutly denied by one who seems to write from authority, or who at least is evidently well backed by a strong party. The writer is evidently one of the Commissioners who met in Paris some years ago to inquire into the working of the quarantine laws. I offer no opinion on the subject,—though “one-idea” men, they have a show of truth on their side, and especially in this, that they adopt the popular view of the subject when they deny the contagious nature of the plague. They boldly affirm that plague only spreads in places where sanitary regulations are despised—a consoling and useful theory, even if it were not true. They made the same assertions of cholera—their hypothesis proved sadly at fault. The pump-well water-drinking theory is the latest expression of medical theorists in respect of the origin of the cholera: there never was a greater delusion. It does not merit a refutation, and is quite unworthy the professors of even a conjectural art. That the symptoms of cholera strongly resemble the action of a violent poison taken into the stomach, is not to be questioned, and that water may have been the vehicle of such a poison is neither impossible nor even improbable. The iced-water drinking population of Paris, of Palermo, and of many Sicilian and Italian towns, suffered terribly from cholera. Nor does it spare the temperate Mahometan, upon whom cleanliness is enjoined as an article of his faith. Still, the wholly inexplicable facts in the spread of cholera (and the same may be said of plague, typhus, and yellow fever) are far too numerous to admit of any generalization. Whilst the cholera spared Birmingham—at the time neither properly drained nor sewered, it nearly depopulated Bilston, a healthy town situated only a few miles from Birmingham, hundreds in the meantime travelling between the two places every hour of the day. It swept off the inhabitants of one side of a street in Deptford, leaving those on the other side unscathed. All drank of the same waters. The theory merits no attention.

14 It raged most severely in Scotland, in the remarkably healthy village of Prestonpans and Fisher-row; in the highest and healthiest parts of Edinburgh; amongst the peasantry and miners scattered over the high grounds of Midlothian, belonging to the Marquis of Lothian. These people lived comfortably in detached cottages amongst the fields.

15 This question, in so far as regards a military life, has been handled in a masterly manner by Major Tulloch.

16 In the expedition to St. Domingo, the English army forming the expedition landed 10,000 strong; they withdrew in five weeks, without striking a blow or seeing an enemy. Their numbers were reduced to 1100. See “History of the

Expedition to St. Domingo," by Dr. Maclean.

17 Persius, Sat. Napoleon expressed the same idea when he said, "The stomach governs Europe."

18 It has been asserted on good authority, and not contradicted, that the "Natural Theology" of the celebrated Paley is a mere translation of a Dutch work.

19 This principle, so fertile in ideas, will one day, no doubt, be fully elaborated and studied to its results. These living beings may prove to be the syphons of perfume and the messengers of colour.

20 For Note on this subject, see page 54.

21 "Statistical Report on the Sickness, Mortality, and Invaliding among the Troops in the West Indies." Prepared from the Records of the Army Medical Department and War-Office Returns. London, 1838. It has been objected to these Reports that they embrace only one class of lives. But this does not diminish their value, for the lives they report on are presumed to be the selected lives of men in the prime of life.

22 The army of England is, and perhaps has at all times been, an aggressive army, maintained to intimidate foreign races and nations. It resembles in many of its main features the army of ancient Carthage.

23 Report: Section, Mediterranean.

24 It may be asked, Why not inquire into the statistics of fever in Essex? The truth is, that no such exist. The conjectures and recollections of civil practitioners are valueless.

25 As by the Registrar-General: see his Reports.

26 The ancient Egyptians seem to me to have long ago settled this question, practically. On the subsidence of the Nile they, without a day's delay, commenced agricultural operations; nothing was allowed to fall into rottenness or putrefaction.

27 Liebig.

28 Liebig: Letters on Chemistry.

29 Report, p. 176.

30 Liebig, 1851.

31 Traité de Chimie Organique. Par M. J. Liebig. pp. 88.

32 Liebig, *loc. cit.*

33 The “Sunderland Times” gives publicity to the following frightful narrative, drawn up by Captain Edward Robinson, of Sunderland, commander of the ship *Raleigh*, of South Shields:—“I arrived at this place in the beginning of May, 1858, being sent to bring home a vessel whose captain died of yellow fever; little did I think, before leaving home, that I should have witnessed the sufferings of so many of my fellow-creatures that were ill of this dreadful epidemic. I was told it would be all over before I arrived, but I found that, so far from that being the case, its ravages were unmitigated. In the street that I lodged in, five in one family were buried from the house in one day. The Rio journals were publishing in their columns, ‘No cases of yellow fever to-day.’ One ship at the port had seven captains dead before she could be brought out of the place. The vessel—the *Raleigh* of South Shields—that I have come home in command of, had her captain, chief officer, second officer, and four of her crew stricken down by the disease. On the day before the Captain died I visited him at the hospital; I there witnessed such sights as I hope never again to see—poor sailors in the height of the fearful malady, with the black vomit, vomiting dark fluid like coffee. I shall never forget the looks they gave me, and how their poor dull eyes brightened as I gave them a word of comfort, and told them they would get better. Next day, when I returned to see them, I found the whole gone—the captain and six of his crew, all dead and buried. Still, ‘No cases of fever,’ say the Rio journals. The number carried off by yellow fever from February to May, 1858, amounted to 1609, upwards of 600 of the deaths being among English sailors. The presence of a plague fever is not to be wondered at, the state of the town being a disgrace to civilized people. All manner of filth is to be met with in most parts of the town. Dead animals and filth I cannot describe meet your eye and offend your senses almost everywhere.

“My brother, now sixty-eight years of age, and who has been thirty-six years at Rio, informs me that he has often seen Europeans on ’Change in the morning, who died and were buried on the same evening. He has seen Rio cleared five

times of Europeans. The pestilence, he believes, comes from the flat marshy land near Rio. The natives burn tar-barrels to purify the atmosphere."

34 Deuteronomy xxii. 12.

35 The Registrar-General consoles the inhabitants of London on the relative amount of injury, being in favour of the plan of polluting the Thames rather than of gradually abolishing cesspools.

36 "Letters on Chemistry." By Justus von Liebig. London, 1857.

37 Liebig, p. 384.

38 The guano of sea-birds when exposed to rain is of no value.

39 Liebig.

40 Henle, "Untersuchungen," p. 52; also p. 57.

41 The expression of Lord Raglan when he demanded from England veteran troops, and not lads of immature age, to be sent to the seat of war.

42 Reign of Charles the Second.

43 He is, I believe, a physician and an M.D.

44 Quetelet.

45 Cholera has not, as yet, passed into the southern hemisphere beyond the tropical line.

46 "The town of Port Antonio is situated at the north-eastern extremity of the island, eighty miles from Kingston, and lies in a hollow surrounded by an amphitheatre of thickly-wooded hills. Fort George, in which are the barracks for the troops, is built at the extremity of a peninsula, nearly surrounded by the sea; and though possessing no great elevation, it has, from its position, a tolerably free exposure to the breeze. On each side of the peninsula are two harbours for the shipping; that on the east side enjoys a comparatively healthy locality, but that on the west is sheltered by a thickly-wooded hill, which impedes ventilation; and there is a considerable space of level ground, generally inundated by the

tide, which at low water is left in a marshy state, and when acted on by the sun emits exhalations said to be both offensive and unhealthy.

“The barracks stand about twenty yards from the sea, on a piece of ground of coralline formation, and consist of a building of two stories, elevated on brick pillars. The hospital is built on a higher situation, and raised on arches about seven feet. It contains three wards for the patients, and has a shaded walk attached to it for convalescents. Water is supplied to the troops, by contract, from a river a quarter of a mile distant.

“There seems to have been no troops at this station in 1825 and 1826, but the mortality during the other years embraced in the Report has been as under:

Years.	Strength.	Deaths.	Ratio of deaths per 1000 of mean strength.
1817	177	34	192
1818	135	12	89
1819	130	45	346
1820	143	12	84
1821	82	18	219
1822	194	10	52
1823	79	4	51
1824	108	21	194
1827	32 *	3	94
1828	129	19	147
1829	133	31	233
1830	155	21	135
1831	161	20	124
1832	157	29	185
1833	164	37	226
1834	185	32	173
1835	154	18	117
1836	160	4	25
Total	2478	370	...
Average	137	20	149·3

* 127 men were here for one quarter of a year only, which is equivalent to 32 for

a whole year.

“Thus the local circumstances remaining the same, the mortality from fever yet varies exceedingly. It is the same with the typhus of temperate countries, showing that in addition to malaria, presumed to be ever present, a something more is required, that we must look for in the constitution of the atmosphere.”

47 I am free to admit, with Liebig, that the lungs are the seat of the most rapid and powerful chemical action (p. 151), yet some distinguished physiologists think that the external integuments may become the seat of disease, and give origin to dangerous affections by mere stoppage of their secretions and excretions. Certain of these are held to be poisonous and highly irritating, and cholera itself has been ascribed to the sudden transfer of the tegumentary secretions into the general torrent of the blood. This seems to have been the opinion of the celebrated anatomist and physiologist, De Blainville.

48 Citrates, tartrates, acetates.

49 Eremacaasie: Liebig.

50 All constitutions are not equally liable to be affected by morbid poisons. This has been proved as regards dissecting-room wounds; and as regards typhus, cholera, plague, ague, &c., the matter admits of no doubt.

51 Blood has a *mordant* given to it which dyes it red; when this is in excess, the blood becomes black, or very dark. This was the colour of the blood in cholera. Its crasis seemed to be broken down, and I have it on sure anatomical testimony, that in dissecting those who had died of cholera, the larger veins, when once opened, continued to pour out blood for many days.

52 The various plans for the deodorization of cesspools, water-closets, dead-wells, sewers, &c., were first introduced into England from France and Belgium. Under French management Paris is sweet, and proverbially clean and pleasant; London, under the management of parties without individual responsibility, notoriously filthy and full of bad odours. Under certain circumstances, and especially when limited to small quantities of the matter to be deodorized, they are successful enough in destroying the unpleasant odour, but in the experiments made a few years ago on the comparative merits of various kinds of deodorants, it was obvious that no real dependence could be placed on them, unless the

cesspool was at the same time flushed or cleansed out with a very strong flow of pure water poured in along with the deodorant. In how far the various deodorants recommended are at the same time disinfectants, has never yet been shown.

The *excreta* deodorized have hitherto proved of but small commercial value, farmers very generally declining their use. It is singular that the same *guano* (human) which is said to be so valuable in China, should prove a failure in Europe, and especially in England, showing how much still remains to be discovered in practical agriculture. If human guano really be of such value in China as has been reported, might it not be worth while to import into Britain a few Chinese agricultural labourers and gardeners thoroughly acquainted with the agriculture of their country, and from whom might be learned the art of preparing the manure? Capitalists have engaged in many less promising speculations than this.

From whatever source the Chinese derived their knowledge of the domestic and fine arts they now possess (for it is impossible to imagine that they invented them), one thing is certain—that they were recording eclipses, printing books, building temples, raising crops equal to the support of a vast population, whilst the great nations of Western Europe were wandering about in their native woods, clothed in the skins of animals, ignorant even of agriculture, and barbarous to the last degree. Nor was the knowledge and taste of the Chinese confined, in the matter of agriculture and horticulture, to the merely useful, as is obvious by a passage in Humboldt's "Kosmos," wherein the illustrious savant proves that the ancient Chinese, in respect of taste in horticulture, and in the composition of park scenery, excelled all the world.

53 Ozone is said to oxidize the poison. It destroys sulphuretted hydrogen and all oxydable miasms, and is the most powerful disinfecting agent, but is itself unfit for respiration: it causes suffocation. Air in its normal state contains one ten-thousandth part of ozone; when raised to one two-thousandth part it is sufficient to kill small animals.

54 Hydrogen, or inflammable air, is the lightest known substance; its specific gravity is to that of air as 732 to 1000. The gases, into the composition of which it enters, rising from these ditches and banks of mud carry with them dried humus, and even animal matter in a state of putrefaction, which, being dry or moist, may act as strongly as variola itself, in respect of its injurious effects on man, who breathes it either as it rises from ditches, or is driven by currents of air

circulating round watery places covered with humus. It is even (*onctueux*) so strong that it will sustain seeds and dust upon water, as I have witnessed at Amsterdam, Rotterdam, Verona, Bologna, Venice, and even in the canals of Lambeth and Deptford. By means of hydrogen we raise a balloon; can we not imagine it to be equal to the raising up of humus? It is generally supposed that sulphuretted hydrogen is amongst the dangerous miasms, but it cannot be so hurtful, for no boat can go into canals without disturbing it, and yet we see no evil results from this; but if the water-level lowers, and leaves vegetable or animal matter upon mud in a state of slow combustion, then it is that fevers commence—a fact, I think, I have proved by an appeal to the history of pestilences in ancient and modern times.

55 "Decline and Fall," vol. iii. p. 391, Milman's edition.

56 The idea of employing the drainage of towns, partaking under all circumstances more or less of the nature of sewage—using the term in its most extensive sense, as comprising the excreta of the entire population—seems first to have originated in Scotland, and especially in the vicinity of the capital. The period is perhaps not well known, but about the commencement of the present century we find the system in full force, but limited to the great outlets of the drainage and soiled water of the town. These great drains were not strictly speaking sewers, but drains, for at that time there were but few sewers, properly so called. If cesspools existed, they were not emptied into the drains, or so-called town-sewers, so that the matters contained in the two great outlets used for the purposes of *foul-water irrigation* bore little or no resemblance to the turbid, frightful, and most putrescent mass *now* conveyed into the Thames by the sewers of London. This essential distinction in the quality of the material has been ignored or passed over in the Reports of the Board of Health. Not that the irrigating water was to be considered as pure; on the contrary, it was extremely filthy; but it did not *at that time* contain the sewage of the town, properly speaking. It probably now does so in consequence of the extension of the system of water-closets, latrines, &c. The Scotch agriculturists who employed the water of these vast foul drains, would have much preferred *pure water*, but they had it not at their command. With this, such as it was, they irrigated certain tracts of land, some of which were originally barren wastes, converting them into meadows on which grew a peculiar kind of grass, which cattle (milch cows) do not reject after having been accustomed to its use. But the farmers knew well that the abominable liquid they thus poured over their fields was wholly unfit for the usual agricultural purposes; and thus in no instance did they employ it as

manure. The Grange drain was used by one market-gardener only, simply for the purposes of irrigation during droughts, but not with any view to the manuring of the garden. By the time that all the cesspools of London have been poured into the drains, and the system of drainage and sewage completed and formed into one system, there arises the question as to how the material is to be disposed of? The pouring it into the Thames at a point below the influence of the tide is perhaps, after all, the easiest and least expensive mode of escaping from the dilemma into which the capital has been brought by the clumsy experiments of the late Board of Health; but what the ultimate result of this additional experiment may be, no one can foretel. If transmitted to the fields, the farmers are sure to reject it as manure; but it might be conveyed to barren waste lands, mere sandy wastes, the qualities of which no doubt in time it would beneficially affect, converting them first into meadows, and possibly afterwards into land favourable for the growth of certain green crops. The liquid might also be conveyed to estuaries which it might be desirable to fill up, and the numerous small tidal harbours which the extension of railways will speedily render of little or no value to the inhabitants.

The mud deposited in tidal harbours or on the banks of rivers within the influence of the tide is of no value as a manure; when spread over the fields, the result is the loss of the crops for some years.

57 Gibbon.

58 Niebuhr.

59 Extremique hominum, Morini Rhenusque bicornis. *Æneid* viii.

60 “Ab urbe condita;” from the building of the city (Rome), the era fixed on by the Romans.

61 This question was first agitated in the reign of Justinian, on the occasion of a proposal on his part to form a treaty with the negroes of Abyssinia. But the Abyssinians were not negroes.

62 Trajan’s wall, between the Danube and the Euxine, at Kostenjie.

63 There were no medical men in Rome for the first five centuries of her great career; and some have fancied that this fact explains the astonishing number of armies which the republic found no difficulty in sending into the field.

64 When unassisted by other deleterious influences, the poison, though all but universal over the locality, may not be destructive. After the draining the Lake of Haarlem, the principal physician of the district informed me that in 2000 cases of ague he had not lost a patient.

65 The choleraic ferment traversed in ships, no doubt, the Atlantic, as typhus had often done before; but there are grounds for believing that vegetable and animal matters in a state of rottenness (fermentation), floating about in the air, are not unfrequently transported to great and almost incredible distances. Ehrenberg and Humboldt have particularly insisted on this fact, and have spoken of distances traversed by these fermentable elements, which I hesitate to quote from memory. Assuredly they were very great, extending to some hundred miles from the seat of their origin.

66 England has often paid a high price for the first steps in science. Mr. Papillion, in 1806, received from Government 10,000*l.* for the introduction of dyeing Turkey red; and his success was owing to his knowledge of the water proper for the operation, which must be void of fermentable bodies.

67 The ammonia always present in the atmosphere is probably derived chiefly from the union of nitrogen and hydrogen; but much of it also no doubt has its source in the fermentation of animal and vegetable remains.

68 Baron von Lynden.

69 I have known many persons sickly from the effects of intermitting fever or malaria from a residence in warm climates, and who have suffered and perished from an injudicious treatment. Ill-formed or incomplete agues are extremely common, even in the south of England, in London especially. They show themselves under a variety of forms, and with much severity, in the cases of those who, having once visited a true malarious climate, are ever afterwards more or less liable to a return of the disease. Let men reflect; simple truths travel slowly, yet are truths notwithstanding. The death of the well-known M. Soyer was evidently caused by his wholly misunderstanding the nature of his complaint, which, in fact, was a fever originally caught in the Crimea.

70 A friend who resided long on the Grotevisch Rivière, and in het land den Caffre, informs me that if the Zuureveld be ploughed up, or altered by the burning, for example, of a Caffre hut, the sour grass, whence the district derives

its name, disappears, and sweet herbage of various kinds take its place. None of these exist naturally in the district, so that the seeds must come from great distances.

71 The effects of partial and incomplete drainage have ever been the same. In 1823, when the new Polder was made at Neusen-on-the Sheldt, small-pox raged in the neighbouring villages to such an extent that the children were forbidden to attend school. The effects are to be seen now in persons over sixty years of age, bearing the marks of the epidemic. The whole atmosphere of the district was infected.

72 *Law* being no body, and quite irresponsible, the blame of these cruel experiments on the health of the population cannot readily be brought home to any one.

73 It is to be remarked that the specific gravity of ammoniacal gas is 53·619; can it be wondered at that this gas should carry bodies from waters which are in a state of slow combustion; during its transit through the air it may even become caustic ammonia?

74 *Purification of the Thames*. A Letter by F. O. Ward, Esq., addressed to William Coningham, Esq., M.P. London: Renshaw, Strand.

75 It is mentioned in the Report on the Wine Disease in Portugal, that the *oidium* was first discovered at Margate; if this was the case, might it not have originated from the phosphorescent beings in sea water, observed by all travellers in the evening on the coasts of Flanders, and known in Holland as Zee Vlam? The potato disease is thought by some to have sprung from the same cause.

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