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THE SCOTTISH GEOGRAPHICAL MAGAZINE.

REMARKS ON MALARIA AND ACCLIMATISATION.

By H. MARTYN CLARK, M.D., of Amritsar.

(Read at a Meeting of the Society in Edinburgh, April 1892.)

UTTERLY unknown in the Arctic and but feeble in the temperate zones, malaria acquires its greatest intensity and works the most deadly havoc in the torrid zone and in lands adjacent to the Tropics. As regards geographical distribution, it girdles the globe. It is rife in portions of Southern Europe, and sometimes manifests itself in the central and northern parts of the continent. It still lingers in certain places in our own islands, notably in the Lincolnshire fens and in the Kentish marshes; but it is greatly circumscribed in area, and has lost so much of its virulence that even these parts of the country will doubtless in time be as free from malaria as other districts in which it was once a deadly scourge.

In our own country, as in Europe generally, malaria occurs chiefly in marshy districts, along the courses of rivers, especially of those which overflow their banks; while in northern regions it is confined to moist situations, in the south of Europe it is met with in tracts which are not ordinarily marshy.

So also in America it becomes more general in its distribution and more virulent in its effects as we approach the Tropics, where it attains its fullest intensity, while in the temperate zones it is confined to swampy localities.

In Asia and Africa it is met with under the same conditions. It is the scourge of India, China, Burma, and the Malay Archipelago, and is found also in Australia; in short, it prevails in every land from the Equator to within five or six degrees of the Arctic and Antarctic circles.

According to M. Boudin, the northern limit of malaria is the isothermal line of 5° C. (41° F.). He states that malarial fevers have

been rife at Gefle, in Sweden, $60^{\circ} 40'$ N. latitude, and he has heard of them even further north. The southern limit is still uncertain, and has been variously given at from 25° to 30° S. latitude.

Not only is malaria, within these limits, world-wide in its distribution, but it is the most deadly scourge of mankind. According to the testimony of Sir Joseph Fayrer, Dr. Cornish, Dr. MacCulloch, and other authorities, it is the cause of half the deaths throughout the world, and in India carries off twice as many persons as all other epidemics put together.¹ But the deaths due directly to malaria are no complete measure of its dreadful effects, for many constitutions are ruined by the secondary affections induced by it. It presents, therefore, a formidable barrier to the spread of colonisation and civilisation. What is malaria? is, therefore, a most important question; and, as MacCulloch tersely observes, perhaps the best, as the truest, account of the nature of malaria would be an acknowledgment of utter ignorance on the subject. Despite the many researches made, our knowledge cannot yet be considered adequate, nor can we, as yet, be said definitely to have found the poison of malaria.

The theories that attributed the disease either directly to marshes and their vegetation, or to the production of marsh and other gases, to deficiency of hydrogen or excess of ammonia, are now abandoned. The peculiar symptoms of malaria cannot be explained by any variation in the volume of those gases, and Bourdel has shown by experiments with water collected under varied conditions, and air from marshy places, that the microzoa, microspores, filaments, and bacilli they contain do not cause intermittent fevers. Another theory, that malarial fevers are simply due to chill after exposure to great heat, is met by the facts that many persons subject to chills are not attacked by malaria; that chills are common in countries where malaria has disappeared; that the symptoms of the disease—the peculiar fever, discoloured skin, disorganised blood, and the organic changes in the spleen and liver—do not follow mere chill; and that young children and other persons who do not labour in the hot sun are attacked by fever.

In 1866 Dr. Salisbury of Ohio announced the discovery of a special *alga* (*Palmella gemiasma*) which he assigned as the cause of intermittent fevers in the valleys of the Ohio and Mississippi; and, though his conclusions were not fully accepted, he gave a new impetus to research. Among other micro-organisms set forth as the cause of malaria were Lanzi's germ ferment (*Vacteridium brunneum*), 1866, Eklund's fungus (*Limnophysalis hyalina*), 1878, Klebs and Tommasi-Crudeli's *Bacillus malarie*, 1879, and Laveran's *Oscillaria malarie*, now known as *Plasmodium malarie*, 1881. The observations of Klebs, Tommasi-Crudeli, and others in the Roman Campagna resulted in the discovery of a microscopic fungus about nine micro-millimètres in diameter, which they named *Bacillus malarie*. It exists in great quantities in the soil, water, and air of malarious localities. With a temperature not under 20° C., humidity, and a supply of oxygen, it develops rapidly, and the spores are found in

¹ Annesley's *Diseases of India*, vol. i. Oldham's *What is Malaria?* p. 2.

the blood, spleen, and marrow of the bones of persons dying from malarious fever. The germs are not found in all marshes, and, on the other hand, exist in soils which have never been marshy. A septic ferment, often present in marshes where the bacillus exists, has been shown by Crudeli not to be a necessary factor in the production of disease. These observations throw light on some of the known facts of malaria—its occurrence at considerable elevations and at places removed from marshes, ponds, etc.

In 1881 Laveran claimed to have discovered in the blood of malarious subjects, in connection with the red corpuscles, rapidly moving filamented spherical organisms of about the same diameter as the corpuscles. Another set of bodies, pigmented like the former and finely granular or transparent, with a diameter of one-hundredth of a micro-millimètre, seemed to be the ultimate forms of the filamented bodies, while a third set were evidently altered blood corpuscles. No doubt the flagellated bodies are living organisms which attach themselves to the red corpuscles and ultimately destroy them. Laveran found this parasite present in 180 out of 192 cases of malaria in North Africa. This view, that malarial fevers are the result of disorganisation of the blood, and the effect of this disorganisation on the nerve centres, would explain many of the symptoms, such as liver and spleen lesions and that grave *Dyscrasia melanæmia* in which free masses of pigment are found in the blood. But of the life-history of these animalculæ, and of the mode by which they gain access to the blood, nothing is known at present, and Laveran's theory cannot yet be finally accepted; Lewis has described very similar organisms found in the blood of healthy animals. Many investigators, however, who have followed in Laveran's track, have corroborated his testimony, and hence there is a growing consensus of opinion that malaria is due to the introduction of *Plasmodium malarie* into the system; that it attacks the red blood corpuscles, lives and grows within them, and finally disintegrates them. It is impossible to over-estimate the importance of these observations; we seem now to be really grasping the truth concerning the cause of malaria.

At present, the sum of our knowledge seems to be this: that malaria is an earth-born poison; that it appears to proceed from those elements which exist in soil and nourish animal and vegetable life, if the said elements be allowed to lie fallow and are not fully expended in the growth of healthy vegetation; that under such circumstances malaria is produced if the conditions of temperature, moisture, and air be favourable. Though the precise nature of the poison is still undetermined, the conditions under which malaria is evolved, and certain other practical facts concerning it, are well known.

As a general rule (for altitude may have a modifying effect), marshy places, low lands, and lands subject to inundation are the chosen haunts of malaria. Deep, rich, absorbent soils, argillaceous or alluvial, are in my experience another favourite abode of the poison, which also flourishes in bottoms, valleys, and confined places, such as a plain hemmed in by hills or sheltered from the prevailing winds, so that stillness and stagnation are produced. Such places are usually rich in organic remains; and

malaria will flourish the better where there is a luxuriant vegetation, for, in a tropical land, this indicates abundance of moisture.

In India (the land best known to me) rivers and streams, almost from their sources to their mouths, are some of the chief haunts of malaria, and prime factors in its production. Having but a slight fall, they wind sluggishly through the vast plains, and, though confined in the summer to a single channel of no great width and depth, inundate vast tracts of country during the rains, allowing their waters to permeate the soil for considerable distances. For example, the Indus, which is but a quarter of a mile wide in the hot season, becomes 18 miles wide at Dera Ghazi Khan, and takes 12 hours, and not infrequently from 18 to 24 hours, to cross. In its last great flood, in 1889, in one portion of its course, this river inundated close upon 700 square miles of country. As it receded, vast lagoons were left, and as they slowly evaporated, during a period of five months, malarial disease became very rife. The unhealthy time is not during the rains, but when the inundated lands begin to dry.

The permeation of adjoining lands by the waters of a river, apart from inundations, has not received notice. This is a great factor in rendering tracts of land through which a river flows unhealthy. The distance from the banks to which water permeates will depend on the nature of the soil. I have seen wells affected at a distance of a mile and a half from the river. Again, at the mouths of the rivers, low and large islands are formed by alluvium, which are as unhealthy as marshes, and bars are thrown up, over which the waves dash during storms and high tides, converting large tracts of country into salt-water lagoons, which are also fertile sources of malaria. If, in addition, we think of the amount of organic matter an Indian river holds in solution, of the filth that drains into it, and of the carcasses consigned to it, we shall see that, independently of its malaria-producing power, it is a serious danger to public health, for it often constitutes alike the sewer and the water supply of the districts through which it passes.

The second great malaria-producer in India is the jungle, which clothes the valleys, the plains, and the sides of low hills. There is a great difference between a forest and a jungle; the former consists of lofty trees, while the latter is clothed with grass, small shrubs, and succulent plants, forming a dense undergrowth. The soil is rich, but not under cultivation; and we have a dense mass of vegetation, a moist, stagnant atmosphere, and a soil which, after heavy rain, is soaked with water—for the roots of the plants hold the rain-water, and part with it slowly, so that a hill-side becomes for the time almost a morass, which as it dries becomes a source of malaria. In addition to rain, heavy dews keep up the process, of which those who have not been in India can have no conception. They soak the ground as rain would do, and make a tent so wet that it is impossible to strike it until the sun has dried the canvas.

The water-retaining power of plants is very great; thus moss (*Hypnum*) under conifers absorbs up to five times its own weight of water, *Sphagnum* (peat moss) up to seven times its weight, and leaf-mould in a middle-aged beech forest can actually absorb and retain no less than five inches of rainfall. In a jungle, not only is malaria produced,

but there is no check to its dissemination, as the winds blow it in all directions. One of the most deadly regions in the world is the Terai, a strip of country lying at the foot of the Himalaya, about eighty miles in breadth and several hundred miles in length. It is covered with dense jungle, the soil is rich, with abundance of both surface and subsoil water, and the temperature is high. The result is malaria-production of the most intense kind, so that the district has been uninhabited for many years. Government has made many efforts to reclaim it, but as yet with very doubtful success. Roads have been made, canals cut, railways projected, and villages planted; the fight with malaria has been steadily carried on with a fearful sacrifice of human life. The teeming population from the south persistently sends out fresh emigrants, who bring their ploughs and cattle and household gods, and build themselves houses, sometimes to succeed, sometimes to fly back panic-stricken after an unhealthy season, leaving half their number under the sod.

What happens on a large scale in the Terai happens all over India on a smaller scale, as the result of malaria-production in jungles.

The influence of a forest is somewhat different. If we take as an example what foresters term a "high forest" (that is, one in which the trees have sprung from seedlings, and are destined to grow to a large size), we find that at the earlier and middle period of its life the crowns of the trees form a dense canopy overhead; the ground is covered with *humus*, that is, leaf-mould undergoing decomposition, and is shaded by the trees alike from the direct and oblique rays of the sun, and, moreover, the crowns intercept directly no less than one-quarter of the total rainfall, keep the air from the soil, and break up the currents.

Such forests have a marked effect on the surrounding country. Being cooler by day and warmer by night than open country, they render the climate of the neighbouring districts more equable, and they have a similar effect in moderating the extreme temperatures of summer and winter—great advantages in an Eastern land. As regards malaria, the formation of miasma is hindered by the shade, and the poison that is developed, being intercepted by the trees, cannot spread freely over the country. Later on, however, circumstances change; the trees thin out in course of time, the canopy overhead is interrupted, the crowns of the trees that are left, instead of being dense and compact, spread out on all sides. Mosses begin to disappear, and grass takes their place. Sun and air now begin to play on the *humus* and soil, which receive almost all the rainfall; the conditions now begin to approximate more to those of the ordinary jungle, and the forest may then become as dire a focus of infection as any jungle can be. I have often noticed that people living in dense forests seemed to enjoy immunity from malarial fevers as compared with those dwelling in tracts where the forest had become like a sparsely timbered park. I have been writing of ordinary forests; but there are certain wet, close woods which are very pernicious in their effects, the cause of the trouble probably being, not the wood, but the wetness; the soil is usually a rich, absorbent loam, the vegetation is rank, and as there is no drainage, the factors of malaria-production are present in abundance; such a place would be deadly even if there were no wood.

Alike in forest, jungle, and ordinary land there is one factor present in the East which, though it may have no share in the actual production of malaria, yet tends to vitiate the air, lower vitality, and predispose to disease—I refer to the superabundant animal life, more especially insect life. To say that insects swarm is a feeble expression. I have seen clouds of mosquitos so dense as really to resemble a heaving solid mass in the air, much like a very large number of fish struggling in an utterly inadequate supply of water. After the first rain, the queen of a species of ant or termite which I have not been able to define issues from the ground. She is about half an inch long, and has two wings like those of the crane fly or “daddy-long-legs” (*Tipula oleracea*). After her hymeneal flight she drops the wings, and retires into the earth to fulfil her function as the mother of future colonies. To give some conception of the numbers of these insects, I may mention that one morning after a rainy day in July the gossamer-like wings swept together in one room only of my house formed a heap two feet in height and about two and a half in circumference, though myriads of the queens must have been eaten the evening before by birds, which were busy devouring them on all sides. This relates to one species of insect only, but there are hundreds of others equally numerous, such as ants, beetles, butterflies, gnats, hornets, flies, wasps, and also swarms of land frogs and other reptiles. This vast quantity of animal matter decaying in jungle and marsh, forest and open land, though it may have no share in the actual evolution of malaria, affects the general health, and thus paves the way for the ravages of disease.

It is an axiom with us in the East that any low-lying land, with a quickly growing, luxuriant vegetation and a superabundance of insect life, is almost certain to be pestilential. Clearance of soil, cultivation and cutting down of forests do not necessarily remove the evils which produce malaria. It has, indeed, often happened that the outbreaks of disease have been greatly intensified by such clearances. Malarial soil covered by leaf-mould, protected from air and sunlight, and to some extent from moisture, by trees, which also intercept malarial exhalations, is manifestly less dangerous to a community than the same soil denuded of its trees and exposed to rain, sun, and air. It is far more dangerous to have such a soil covered with grass and jungle. When the protecting trees have been removed, the soil, saturated with animal remains and accumulations of vegetable matter, is placed under the most favourable conditions for the development of malaria; and the result is that localities once fairly healthy become fever-stricken, while those which were affected by milder forms of fever become pestilential. The danger of turning up the soil and exposing it to sun and showers has often been exemplified. There was a great outbreak of malarial disease in Paris when the Canal St. Martin was excavated. A most fatal fever devastated Hong Kong when the hill behind the city (Victoria) was broken up for building purposes. Labuan was ravaged by malaria when the harbour works were constructed, and, in my own experience, the laying out of some eighty miles of new railway, which entailed a good deal of earth-work, was accompanied by severe malarial fevers. Drainage, clearances, cultivation will eventually win the day against malaria; but, to avoid risk of

infection and loss of life, it is necessary to proceed with caution. The ground should never be laid bare, but should be sown while the trees are still standing; and as regards buildings, excavations, and all operations which entail the breaking-up of soil, it is most important that they should be carried on when the chances of rain are least—and, inasmuch as the seasons are very regular in tropical lands, a fit time may easily be chosen.

We have hitherto considered malaria as it is produced in jungles and low-lying lands, in rich, fertile soils; but it is as prevalent and fatal on the high, sandy ground of the Deccan, in the breezy upland plains of the Punjab, in desert Scinde, in Bhawulpore, in the Peshawur valley, in many a place without either marsh or jungle, and, in fact, in some which are entirely devoid of vegetation. We owe it to Dr. Crudeli's researches that the idea of *marshes* being the sole origin of malaria has been dismissed from our minds, and that another clew has been placed in our hands. While the old belief in marsh poison dominated, it was impossible to explain rationally the outbreaks of fever in the arid lands of the Punjab and Northern India, in the dry soil of Estremadura, where the British army was decimated by malaria during the Peninsular War, and in other similar instances. We now know that a very slight degree of moisture suffices for the production of malaria, and it is to be remembered that many arid lands are full of enormous vegetative energy. Many hundred miles of land in India, now smiling with rich harvests, were arid wastes before the British irrigation canals were made; and were irrigation to be discontinued, in a few months that fruitful land would turn to barren desert again.

The slight amount of moisture needed may be supplied by dew or rain, but it is generally, I believe, derived from the subsoil. Subsoil water is a potent factor in malaria-production. Its continual rise and fall, which, so far as I know, has never been noted, must have a very great effect. An example will illustrate my meaning. In Amritsar, in the Central Punjab, the subsoil water stands at 10 feet below ground. Irrigation is effected partly by wells. After six hours watering from a well, I noticed that the water-level had fallen 4 feet, so that the subsoil water-level immediately around the well was then 14 feet instead of 10. In six hours the well again rose to its old level. During these hours there was below ground a depth of soil of 4 feet which was practically drying, and thus round all the wells of the district extended many square miles of malaria-producing land. Recent researches of French and German foresters show that the soil is continually absorbing and exhaling air. The depth to which air penetrates depends on the nature of the soil, and has not yet been accurately ascertained. In my opinion, the pressure of the atmosphere on the soil must of necessity drive air into it, and in a porous soil will, in all probability, force it down to the subsoil water-level. We thus have a moist soil acted on by air. Air has also abundant access to the lower strata in a hot country through the cracks and rifts which abound in the soil. Some of the malaria thus produced is doubtless exhaled, as air is driven out by the rising subsoil water, or by the ascent of heated air-currents; but some of it remains and is washed into the wells. This source of infection is most important,

for malaria is doubtless imbibed as well as inhaled. Subsoil water is affected also by summer heat and rainfall, both factors in the production of malaria. It is impossible to over-estimate the important part it plays in the generation of malarial poison. It may be taken as a rigid and unailing rule that, in proportion as the subsoil water is nearer to the surface, so the unhealthiness of a place is increased. Perhaps the most remarkable instance is that furnished by the city of Allahabad in India. This city is built upon the tongue of land between the rivers Ganges and Jumna. The old barracks stood 50 feet above the river, where the subsoil water was 40 feet below the surface. Some years ago new barracks were, for strategic reasons, built near the railway station. They are roomier, loftier, and immensely better than the old ones, with every modern improvement, and the soldiers sleep on the second story, instead of on the ground floor as in the old barracks; but the subsoil water under them is but 12 feet from the surface, and here the soldiers suffer very much more from malarial diseases than they did before. Amritsar was at one time looked on as a health resort. In 1859 the subsoil water was 40 feet below the surface, but irrigation canals have since been made, the land has been systematically flooded, there is no subsoil drainage, the water-level now (1892) stands at from 8 to 10 feet below the surface, and the place has become one of the most unhealthy in the whole Punjab.

Deadly malaria may be present where the surface is composed solely of rock and there is no subsoil water. The most famous case on record is the hill behind Victoria in Hong Kong. The rock is pure granite, but Dr. Maclean notes that it is disintegrated and loaded with fungi, while another observer, Dr. Black, states that it is "so porous that it is something like a mineral bog." In the absence of rain and subsoil water, moisture must, I should think, be supplied by heavy dew. But in all instances of malarial diseases occurring in places where they cannot, apparently, be locally produced, we must not forget the possibility of infection from a distance. Malaria appears to be heavier than air, and, given winds powerful enough to propel it but not strong enough to dispel it, there is no valid reason why it should not be carried very considerable distances. In all abnormal cases regard should be had to prevailing winds as the probable explanation of the problem. Thus, places with surroundings apparently unhealthy are sometimes found to be healthy, for the prevailing winds blow the malaria away from them; and the converse also holds good.

A striking instance of this is presented by the Kangra valley in the Punjab. At certain periods of the year it is a vast rice swamp, which may be safely traversed as long as it is flooded, but as soon as the grain has been cut and the ground begins to dry, the most terrible outbreaks of malarial fever occur. The snowy range of the Himalaya rises up from this valley to a height of 17,000 feet. At the bottom of the mountain, mangoes ripen and the climate is almost tropical, while at the top we have eternal snow, and all gradations of climate between. Now, on the outbreak of fever in the valley, malaria makes its appearance on the hill-side up to an elevation of 6000 or 7000 feet; and it should be noted

that it is not the houses and villages situated on bluffs and knolls which suffer, but those built along the water-courses and gullies that score the sides of the mountain, and up which the malarial poison is blown. Between the high banks of the water-courses there are two currents, a descending one of water and an ascending one of malaria. Above 7000 feet there are no villages, so I cannot say whether the poison goes further; but it appears to decrease steadily in intensity with every 1000 feet of ascent, and the valleys beyond the snowy pass get no malaria at all.

In selecting sanitarium in the hills, or in building houses, regard should always be had to rifts, gullies, and water-courses, and to the not improbable danger of infection from lands below. The density of malaria is also noteworthy in another way. In comparatively flat countries, bordered by hills, any little valley or hollow is a most dangerous place between sunset and a short time after sunrise. As the hot air radiates from the ground, cold air rushes down to supply its place. It trickles down the hill-sides into the hollows, so that the latter become practically lakes of cold air. Colonel Bailey told me a striking instance in his own experience. He once, when in India, pitched his tent at the foot of a bank, about 15 feet below the general surface of the surrounding country, in order to obtain shelter from the wind, and suffered from intense cold throughout the night. The night following he pitched on the top of the bank, and, in spite of the wind, was comparatively warm and comfortable. That in these cold air basins malaria also collects I once had practical proof myself.

One early morning in March, I had to descend a little hill, cross a small valley about 100 yards wide, and ascend another hill on the opposite side. As I went downhill the sun was warm, but the valley still lay in the shade. As I descended into it the intense chilliness struck sharply through me. I crossed rapidly, but before I had mounted 300 yards up the opposite slope, I was in the miseries of the cold stage of an intermittent fever which hung about me for a week. Half-an-hour later the valley was flooded with bright sunshine, and it could then have been traversed with safety. This fact concerning the weight of malaria has its practical application in the measures to be taken for escaping it. A very simple but effective precaution is to sleep above the ground. The peasants of the Roman Campagna sleep in old Etruscan tombs, perched up above the plain; the American Indians sleep in trees; the workmen of the Panama Canal slung their hammocks at night in the highest trees, with the best results; the people of malarious tracts in Greece and in the Pontine Marshes sleep on raised platforms. Sleeping on an upper story instead of on the ground floor confers marked immunity. Hunter records that cases of malarial fevers in Kingston Barracks, Jamaica, occurred in the proportion of three on the ground floor to one on the upper; and other instances might be given.

The production of malaria proceeds as freely during the earlier part of the night as during any part of the day; with this difference, that when malaria is evolved during the day, it is presumably not concentrated but dissipated and carried into the higher regions by the heated air currents. It is otherwise at night. After sundown the heated earth takes longer to cool than the air; in fact, the earth can hardly be said to

become cool except in the early morning. Consequently, the malaria then accumulates on the surface of the ground and becomes highly dangerous. In the East the night is always considered to be the most dangerous time. As soon as the sun sets a peculiar chilliness is at once evident at most seasons, and the danger is enhanced if the air be still and humid. For another reason also the weight of malaria and its method of propulsion by air currents is important. It can, I believe, be deflected from its course by walls or houses; thus, an intervening building may protect another, and the infected air may be intercepted by walls round towns, by the suburbs of a city, or by other obstructions of a like nature. This view has an important bearing on sanitary measures in India. An Indian town appears to be built in defiance of all sanitary laws. A high wall surrounds it. The streets are extremely narrow and crooked; the roofs of houses on opposite sides of the pathway almost touch one another; and the *tout ensemble* violates our theories of ventilation and of other sanitary requirements. Of late years there has been a perfect mania for widening and improving streets, for introducing costly schemes of drainage and water-supply, and for approximating Indian towns to the Western ideal. My observations lead me to think the result unsatisfactory, unless such measures be well considered and the improvements be very carefully executed. In the East everything Eastern is not of necessity bad, nor is a thing which is good in the West always suitable to the East. I believe that thousands of years of experience have, in many instances, taught the people of India what is best for them in matters relating to food, clothing, houses, exposure, sleep, and the details of daily life; and rashly to disregard the practical outcome of generations of experience and to supplant old habits by others, acquired under totally different conditions of life—natural, social, and climatic—is not for the benefit of the people. We should help them to rectify obvious mistakes, and supply that which seems lacking; else, as an old Indian gentleman tersely expressed it, “you will, with the bath-water, also throw away the child.” Now, straight and wide streets and free air-currents are doubtless good, if we can only stop the evolution of malaria round about a city; otherwise, by removing protecting walls and deflecting angles, we do but lay the city more open to the enemy. The narrow streets excluded the sun, which in the broad, improved street beats fiercely on the ground, scorching pitilessly, and causing the most horrible emanations from the open drains and sewers, which are never flushed, and have but little fall. Drainage, again, is comparatively easy in our sea-girt island, with its slopes and valleys and abundant water-supply. It is not so simple a matter in the flat Punjab plains, with hardly any fall, with a limited water-supply, a burning sun, combined with a limited intelligence, and an intense conservatism in these matters—the outcome of a set of social customs, traditions, and beliefs utterly different from our own. Then again, a rich country like ours can afford to buy its food abroad, and to lose millions of pounds sterling annually by letting its drainage and waste run into the sea; but India is a poor country, and the problem is how best to return to the soil what has been taken out of it, in order that its fertility may not be impaired.

A portion of the great city of Amritsar, in the Punjab, has been rebuilt. The new streets are stately and wide, and there is now light and air in the spacious houses, in accordance with Western ideas. Yet the worst cases of malarial fevers, in my experience, have been in this part of the town; and, proportionately, sickness is quite as rife here as in the older part. I do not undervalue the blessings of modern sanitation. Sanitary science has a great future in India; but it must move cautiously. Wide streets will do good when malaria-production ceases.

The effects of screening from malaria by means of walls were exemplified in a great outbreak in Jubbulpore, in Central India, in 1866. Within 500 yards of a swamp stood the Royal Artillery barracks, and between them and the swamp the barracks of the 23rd Regiment (Welsh Fusiliers), which ran in the same direction, and occupied the same extent of front, so that the Artillery were completely screened from the swamp. A most fatal fever broke out amongst the Welsh Fusiliers, 300 men being attacked out of a total strength of 500; but there was not a single case of fever in the adjacent Artillery lines. The Artillerymen were put on daily doses of quinine as a prophylactic, and this doubtless contributed to the result recorded; but as the drug was not issued until after the malarial outbreak had established itself in the 23rd Regiment, the exemption of the Artillery from attack was not, in the first instance, due to it. No doubt the Infantry barracks screened the Artillery from the malaria, or it is reasonable to suppose that the causes which produced the fever amongst the Fusiliers would have had the same effect on the men in the adjoining buildings.

Mian-Mir, one of the largest military cantonments in the Punjab, furnishes another example. Though carefully planned and constructed, it is one of the most unhealthy of all the northern Indian stations; whereas Lahore, four miles distant, on the marshy banks of the Ravi river, a typical Indian town, with a crowded native population in its narrow streets, suffers far less from malaria. Difference of race will not account for these facts, for I have found that the poorly fed and clothed Hindu is more subject to malaria than the European; and, moreover, the British soldier is a picked man, in the full flush of his manhood. We must, it seems to me, conclude that the wider streets give freer access to malaria.

Another curious fact concerning malaria which has come under my notice is that it sometimes concentrates itself for weeks, and even months, in a particular locality. A remarkable instance occurred at Amritsar in 1881, when there was a malarial pestilence such as is seldom experienced even in India. The city stands 1500 feet above sea-level, and is distant about the same number of miles from the sea, so that the fall is approximately a foot to the mile. It is built in a sort of shallow dip or basin about three miles in circumference, forming a part of the great plain extending for about 2000 miles from Peshawur to Calcutta. On either side run the rivers Ravi and Bias, and close by are two very large irrigation canals, from which many million tons of water are annually turned on to the soil; there is no subsoil drainage, and the subsoil water has risen from 40 feet below the surface in 1859 to 10 feet in 1891, and is

still rising. Places that were gardens when I first went there are now marshes. The soil is a deep, rich clay, producing a most luxuriant vegetation, and numbers of large gardens are regularly flooded twice a week with canal water, impregnated with decaying vegetable matter and the remains of numberless reptiles and insects. The city (the largest in the Punjab) is girdled by morasses and marshes. There are many stagnant pools in all directions, consisting of a central mass of putrefying water, thick with green scum, and surrounded by circles of half-dried mud, the outermost having broken and curled up as it dried. The bodies of dead animals not infrequently add to the terrible smell that comes from these pools. Then, as it is a holy city, there are numbers of great tanks built by the pious for the performance of religious duties, which reproduce the conditions of the stagnant pools, and, in addition, receive an enormous amount of organic pollution from the bathing and washing continually carried on in them. The sanitary arrangements are not of the best; the water supply comes from wells, and there is a teeming population, subject at certain periods to great additions by the influx of merchants from all parts of Northern India and Central Asia into this great commercial capital, and also of pilgrims, who come at certain times in vast numbers to the holy city. The conditions are thus pre-eminently favourable to malaria, which is never absent; but in 1881 it developed into a pestilence. In June of that year an abnormal rainfall occurred. The average for fifteen years had been 24·9 inches; but in 1881 it rose to 52·2 in the city, and to 68·5 in the district. Immense lakes were formed in all directions, and the subsoil water rose flush with the ground. As long as the land was flooded all went well; but as the waters began to dry up, malarial diseases appeared in a well-marked sequence—intermittents at first, and remittents when the drying process was more advanced; and in September, when the whole land was bare, malarial fever of a most malignant type broke out and raged through many weeks. The fever was characterised by very severe rigors, high temperature, coma, and death in a few hours after seizure. Nine-tenths of the shops were closed; railway, post, and telegraph offices were worked under the greatest difficulties; grass grew in the streets; and the place looked like a city of the dead. The mortality in two months was about 12,000. From the 19th to the 30th of September 2265 persons are reported to have died; but these figures are much below the reality, because of the reluctance of the natives to give information concerning deaths. At one time the death-rate was calculated to be 600 in the 1000, instead of forty or fifty as it usually is. Two hundred corpses were carried out every day, and thousands of people fled into the country and died there. Many thousands more died in the months after the epidemic had ceased, from secondary disorders; and not a single European escaped attack.

A curious circumstance was that during this terrible visitation a bright grey haze hung over the city, and that there was a distinct, sharply drawn, malarial line. As one entered the city, one felt a marked difference in the air; and healthy European adults, who had just come down from the hills, were seized with vomiting and pains in the limbs as they crossed the malarial line, and had to be taken home. Places

outside the city suffered less, and those in the district some miles away had no unusual amount of malarial disease for the time of year.

During a violent outbreak of malarial fever in the Gujerat district in 1890, when, according to the official returns, only one person in 1000 escaped attack, the pestilence was confined to the one district. A very remarkable instance of the localisation of malaria is recorded by Dr. Divorty. He took a new house in Carlisle built over ground that had recently been much disturbed, and was seized with fever on the first night he slept in it. The singular circumstance was that he could always stop a paroxysm, when he felt it coming on, by going a few yards away from the house.

The malarial poison is usually breathed into the system, but it is, in my opinion, quite as commonly imbibed. Water is contaminated in two ways: either by the power that it has of absorbing malaria which passes over its surface, or, in the case of wells, through the subsoil water, as I have noticed elsewhere; and the reason why some Indian cities have not benefited from new water-supplies is that the water comes from an infected source. This is also one of the causes of malarial outbreaks on board ship in mid-ocean. Streams flowing through the Terai are often very dangerous because of the malaria in them. In 1884 a party of workmen sent to repair a bridge over the Chuka drank of this stream, and out of thirty only three escaped fever, while several of them died. A deep well has now been sunk near the river, and the station has become as healthy as any other. The Forest Department have now sunk a large number of wells, with the result that instead of having to invalid their employés once every fortnight, they are enabled to retain a permanent staff. The streams known to be deadly all rise in dense forest, and are overhung by shrubs and bushes; those bordered by sand or shingle seem to be much less infected.

Milk may probably be another source of infection, apart from the water which may have been added to it. It is a moot point in India whether the great prevalence of enteric fever may not be due to the fact that cows are fed on garbage of all kinds. They become infected with the germ, and there is, consequently, infection of the milk. The same reasoning would apply in the case of malaria. The buffalo, whose milk is largely used, is an animal that delights to wallow in the mud of marshes, and during the hot weather it spends both days and nights immersed in the nearest marsh, swamp, or pond, with only the nostrils protruding. Both it and the cow are watered at the filthy pools I have described. Malaria must enter plentifully into these animals. They are said to have attacks of fever, but of this I cannot speak from personal knowledge. I have only seen one dog which undoubtedly suffered from tertian ague. If the milk can be infected by the systematic infection of the animal, it may be a vehicle of malarial transmission—as it is of tubercle.

The mosquito has, I am convinced, a large share in the propagation of disease in the East. Those who have not suffered from them can have no conception of the myriads of these insects, nor of the intense torments they cause. Their poison is said to be, weight for weight, more

virulent than that of the cobra. They predispose to malarial fevers by the intense irritation, the restlessness, insomnia, nervous exhaustion, and prostration which sometimes result from the injuries they inflict. It may also be that, as some insects carry the pollen of one plant to the flower of another, so mosquitos transplant the malarial germ to a suitable *nidus* by directly inoculating their victims with it. The eggs of this insect are laid in water, and the larvæ are hatched in the mud of swamps, pools, wells, and other stagnant waters. They must, therefore, be saturated with the germs of malaria, and it will probably some day be ascertained that the mosquito fulfils a part in their transmission. This insect has a well-ascertained share in the development of the *Filaria sanguinis hominis*. The question was first investigated by Dr. Manson of Amoy, and thereafter by Cunningham and Lewis, who found that no less than 14 per cent. of the insects caught at random contained filarous embryos. If the germ of malaria prove to be a *hematozoon*, mosquitos and other such insects will be found to have a share in inoculating their victims (1) from the original source of the poison, (2) from person to person, (3) by the contamination of articles of food and of water in which they breed and die.

Though malarial diseases are present all the year round, yet the seasons have a marked influence on their intensity. With us, in India, the two most unhealthy months of the year as regards malaria are September and January, in both of which the land is drying, or has just dried, after heavy rain.

One attack of malarial fever seems to predispose to another; and when once it gets into the system I believe the poison is never eradicated. It lies dormant, but is readily roused into activity by any passing cause; so that a specific malarial manifestation may be the result of poison acquired years ago. Thus, we frequently have cases of people who while abroad have enjoyed perfect health, yet when they come home the change of climate so disturbs the balance of their system that they suffer from severe attacks of malarial fever. They absorbed the poison abroad, but their state of health was then good, and not favourable to disease; but as soon as circumstances changed, the virus asserted itself. Similarly, when the balance of health is disturbed by some passing affection, malarial poisoning supervenes, aggravating or complicating the complaint, or following after it and proving sometimes more formidable than the original disease.

The first year at home is, I am inclined to think, a critical period for those who have been long abroad, just as the first year abroad is a trying one for us when we first go out. In nine years of Indian life I have suffered from malarial fever about eight times. In the one year of furlough at home I have had about thirty attacks—much milder than they would have been in India, but distinct attacks nevertheless. Three friends who came home about the same time have not been so fortunate; some of the severest attacks they have ever had have occurred during their first year of furlough. In addition to the change of climate, there is a change in the habit of life; and probably the lack of mental stimulus that daily official work affords, as well as the great increase in purely

physical exertion, are as potent factors in favouring malarial outbreaks as changes of climatic conditions.

The various malarial diseases in all lands are the outcome of one identical poison, and the effects produced depend on the quantity of the poison which enters the system, its degree of concentration, the seasonal temperature and humidity, and last, but not least, on the individual constitution. That the poison is identical in all lands and in all varieties of malarial diseases, is evident from the broad lines of resemblance which malarial manifestations bear to each other in all quarters of the globe—the periodicity, the specific course of the symptoms, the specific lesions produced by the poison of malaria in the liver, spleen, and blood, and the value of the specific treatment by quinine. These features, however much they are modified by country, climate, or season, yet remain essentially the same. Idiosyncrasy or individual peculiarity in those affected must also be taken into account, for it is difficult otherwise to see why the same poison should in one case produce fever—quotidian, tertian, or quartan—and in another neuralgia, hemicrania, or dysentery. Another proof that the poison, however varied its outward manifestations, is one and the same is to be found in the way in which malarial diseases merge into one another. Thus, when a malarial outbreak occurs, we have, in proportion as the land dries, intermittents, then remittents, and, finally, the most acute form of fever. It is stated that at the commencement of the intermittents the tertian is the common type of fever; as the character of the epidemic grows more severe, quotidians obtain; and as it begins to die away, the fever reverts again to the tertian or quartan type. Remittent fever often passes into intermittent as the patient tends towards recovery; and similarly an intermittent may pass into a remittent fever, and this in turn into the acute form met with in certain epidemics, in which the intensity of the poison very rapidly destroys life.

Though fevers are the chief manifestations of malarial poison, they are not the only diseases produced by it. It has a direct causal relation to dysentery and abscess of the liver; and in addition to these it frequently gives rise to the most varied diseases of other kinds.

The number of diseases of which malaria is the parent is infinite. Even when there is no actual disease present, the poison is inimical to life, especially the life of Europeans. The fevers and other diseases to which it directly gives rise are bad enough; but the true scourge is the chronic malarial infection of the system that goes on day by day. It is this that saps the strength and destroys the life of the individual, and ultimately causes deterioration of the race. It resists remedies in a remarkable degree; and even when the victim has been removed to better surroundings, or has returned to his own land, it causes permanent ill-health and suffering. The infection is progressive, and hence renders acclimatisation to malaria impossible. Certain races undoubtedly enjoy greater immunity from malaria than others: thus the Negro is said to be less susceptible than any other race of mankind, especially the Negroes of the Grain Coast of Guinea. Their country is but a few feet above sea-level, is constantly inundated, and abounds in lagoons, marshes, and rice-swamps. The climate is most deadly to

Europeans, and is unfavourable even to domestic animals. Yet in this unpromising land the Negro flourishes in great perfection. The inhabitants are well grown, very little subject to disease, and, as a rule, live to a good old age. In the rice-growing countries of America also, while the white population suffers from malaria, the black is exempt; and in India, according to Sir J. Fayer, the Tárus, who inhabit the Terai, appear to enjoy comparative immunity from malaria. Individuals doubtless vary in their susceptibility to malarial influence, and in past ages malaria may have been the great acclimatiser, sweeping away all who could not withstand its ravages. This process of elimination may possibly have gone on in the past, though nowadays there are no traces of its action amongst any of the Indian peoples, nor, as far as I know, amongst any race elsewhere. Amongst civilised peoples not only is the selection of individuals and species impossible, but, in addition, medical science strives to keep alive the weaklings of the race by appropriate measures. The white races can never acquire immunity from the attacks of malaria. Annesley records that in Georgia (U.S.A.) white women seldom attain the age of forty, and white men seldom that of fifty, unless they have arrived at adult age before they settle.

In India, where there is ample opportunity for observation, it is evident that with each successive year the European race becomes more and more unfit to bear the climate. There is no such thing, I believe, in existence as a third, or even a second, generation of Europeans in India born and brought up in the plains. Even when brought up in the hills the stock tends to die out in the third generation. European children in West Africa seldom reach the age of ten years. In India, even with the climate of the hills in summer and that of the plains in winter (the two best climates in the world), the life of the European child is beset with many perils. If we consider the high position of life occupied by most of the parents, and the care and provision for children that are possible, infant mortality in India is proportionately extremely large. The children, despite every care, do not thrive after a certain age; they are stunted in growth, and (besides deficient mental and moral development) have little or no strength of constitution. There is a peculiar form of *cachexia*—due to malaria—in children, which is sometimes noticed in mere infants. They become wasted, are always ailing, and do not thrive; physically, a blight seems to rest upon them, while in mind they are rather precocious. Unless they obtain a change of climate such children soon die off; and even after they reach home they require careful attention and treatment before they begin to thrive. Malarial *cachexia* may exist with or without fever.

The effects of Indian climate are equally evident in the youth who is unfortunate enough to go there before his constitution has been fully developed. He suffers greatly from malaria, and either succumbs to it or has to be invalided home, shattered in health. In a case under my own observation, a youth aged seventeen who went from Scotland to India nearly lost his life from malarial fever twice in the first year, and suffered much from long-continued and severe intermittent fever, so that he had to return home. He went out again to the same place, and to a

harder life, when he was twenty-two, with his constitution fully developed, and has hardly suffered at all from malaria. While such are the deadly effects of the malarial poison on young and unformed constitutions, those who go out after they have attained maturity have their constitutions steadily undermined by chronic malarial infection, so that with each year life in India becomes harder. Their bodily fibres lose tone, they become much more susceptible to heat and cold, and less able to withstand the inroads of disease. Acclimatisation is not possible in the plains of India, and even in the hills and in districts beyond the limits of malaria the tendency of the stock is to degenerate and to die out, or else to approximate to the aboriginal. For maintenance of health and stamina frequent visits home are necessary; after the first five or seven years of foreign residence, and at the conclusion of every subsequent five years, are the times when a European in good health should take furlough if he is to maintain his constitution unimpaired; but these terms must be subject to great variation, according to the special circumstances of each case. Prolonged residence beyond seven years is possible, but is not advisable. There must be a longer period of rest and change in such cases to restore the balance of the constitution, and prolonged residence has often reduced the vital and recuperative powers to so low an ebb that the individual has never been completely restored to health. It is to this fact that I attribute the larger number of failures of health in the period of foreign service after the first furlough, where the said furlough has been delayed beyond seven, and in some cases ten, years.

Anything that destroys or lowers the balance of general health predisposes to an attack of malaria; thus the exhaustion produced by heat, and especially by exertion in heat, often brings on a fresh attack of fever, or induces a primary attack. Other diseases, exhausting evacuations, and debauchery all have a share in inducing malarial disease. Indolence has a very marked effect in this connection; excessive indulgence produces satiety and a debility which tends to indolence; and inactivity of mind has its effect on the moral as well as on the physical nature, and is a fruitful predisposing cause of disease. It is an axiom in India that the only way to be healthy during the hot weather is to be busy. A very frequent cause of illness is a chill, for though chills do not produce fever they certainly induce it. Punkahs are a very common cause of chills. They do not lower the temperature, but keep the body cool by keeping the air in motion. The least exertion in the hot weather causes violent perspiration, especially if one is away from the draught of the punkah; and when one is again within its range, rapid abstraction of heat is followed by chill. At night chill is still more common. The nights are sultry and stifling, even with the punkah, and quite intolerable without it. But it frequently happens that the punkah-puller falls asleep, and as soon as the fan stops the bodies of those sleeping under it become bathed in perspiration; in a few minutes the punkah-puller awakes, or is awakened, and pulls violently—the result is a thorough chill. If the punkah is bad, other heat-alleviating appliances which act by directly lowering the temperature of a room are infinitely

worse. Chief amongst them are Thermantidotes and Tatties; in both of these air is cooled by being passed over or through water, and is then conducted into a room. The effect is very marked. A room with a temperature of 100° falls to 75° , and is easily maintained at that heat; but the cooled air is also laden with moisture, and is fruitful of disastrous chills. The irrational life too often led by Europeans in the East is also a powerful factor in the production of malarial disease. After a troubled hot night many people rise at 5 A.M., when breakfast is taken. This is in the *déjeuner à la fourchette* style: there are usually many dishes, highly seasoned, and as the day wears on the combined effect of these and of the heat is to cause thirst, which is aggravated, not relieved, by pegs—a variable amount of brandy or whisky taken in soda-water. Lunch (*tiffin*) at about 2 P.M. is another breakfast; the heavy meal is not conducive to refreshing slumber, and so the afternoon siesta is as troubled as is the long night after a heavy dinner at 8 P.M. All people do not live in this way; of late years there has been steady improvement, and a much more rational mode of life is now in vogue, but there is yet room for improvement in food, drink, and social customs. Abroad we are too much wedded to the traditions of home, and not unnaturally so; but we too often find that habits which, if not actually beneficial, were at all events innocuous in our cold northern clime, are not only unsuited to our new surroundings, but positively hurtful. To most men in India the life is one of intensely hard work under unhealthy circumstances, and the true secret of life is by every means to economise brain and nerve power, and by suitable changes in diet and habits to adapt oneself to the new surroundings.

Into the treatment of diseases caused by malaria it is not necessary here to enter. The preventive treatment of malaria itself falls under two heads—general measures tending to prevent the production of malaria, and special treatment calculated to fortify the individual against it.

The former must be based on the conditions necessary to the existence of the poison, namely, a certain degree of temperature, a certain quantity of moisture and air, and a peculiar condition of soil. In the absence of any one of these the production of malaria is impossible. It may be checked by the temperature falling below 20° C., or by prolonged heat drying the air and soil, or, again, by the exclusion of air from the soil.

Thermal conditions are beyond the control of man, but they should not be neglected. Many lives may be saved if the right time or season be chosen when an army or expedition has to traverse malarial wastes. Moisture is much more under our control, as we can withdraw it from the soil by drainage. But in all drainage schemes we must provide not only for the surface water, but also for the more dangerous subsoil water, and in all systems of irrigation in tropical lands the water after fertilising the soil should be allowed to run off. Where this water cannot be carried off, the supply should be so regulated, according to the nature of the soil, that it may be evaporated, and not go to increase the subsoil water. In India many thousand miles of waste land have been turned into fruitful ground by an elaborate system of canals; but in the absence

of subsoil drainage they undoubtedly become a source of sickness and death to many thousands of people.

Where drainage-works may be impossible, or may be too costly, we may achieve the same object by judicious training of rivers by means of embankments, and we shall thus be enabled to protect great tracts of land from inundations when rivers are in flood, or from the invasion of water at other times. Such simple methods may often accomplish all that drainage would do.

If none of these methods is applicable, we may withdraw another of the factors needed for malaria-production by preventing access of air to the soil. We have remarked that rice-fields—one of the worst haunts of malaria—are perfectly safe while covered by the water needed for the growth of the young crop, and that the dangerous time is when the harvest has been garnered and the fields have dried. And such is the case also with other lands, the virulence of the disease increasing as the drying process advances. The explanation of these facts is, that air being unable to reach the soil through the covering of water, malaria-production ceases. We can imitate this natural process, and attain the same object, by flooding all dangerous lands. I have in India seen large tracts of low-lying, swampy ground near cities, valueless for crops, grazing, or building, and a fruitful source of malarial disease, which might by flooding be turned into ornamental waters, might be used for bathing and boating, and, if stocked with fish, might become a permanent source of supply of a much used and highly valuable article of diet. With a little damming, and, as in many tanks in India, a simple arrangement to ensure a constant inflow and outflow of water, the same level could be always maintained; and thus land that is now an eyesore and a cause of much suffering might, at small expense, be converted into a source of great benefit to the community.

Where it is impossible to flood malarial spots, they may be covered deep with earth; but this plan, though it has been extensively tried in Amritsar, is not to be recommended. Not only is it very expensive, but the digging and upturning of large masses of soil is in itself a source of danger to the community; and as the new earth receives rainfall, and subsoil water rises into it, it may, in its turn, become a focus of infection. Lands reclaimed by covering with soil should never be allowed to lie fallow. In Amritsar, such ground is largely utilised for market-gardens, and thus a welcome addition of food is supplied to the teeming population of the city, and the profits derived go far towards defraying the cost of the original works. But the difficulty is that in tropical lands it is impossible to grow crops without constant irrigation, and thus the new soil is being gradually soaked, while the subsoil water continues to rise; and I believe it will in time be found that the form of cultivation adopted has rendered nugatory the remedy of covering the malarial spots with soil.

Clearance and cultivation are important measures, and of very great value to the permanent reclamation of land. It has elsewhere been pointed out that, while ultimately these measures must prove beneficial, yet the denudation and upturning of the soil may be for some time

followed by most fatal results, and that the true secret of achieving the desired object safely is to clear the ground by thinning the forest very slowly, never more than can be immediately occupied by crops, so that the ground may never be left bare.

A measure of special hygienic importance is the planting of trees. Belts of trees judiciously planted are of the greatest service. By absorbing carbonic acid and giving off ozone, they purify the air of a locality. In malarial districts they have a special value—not only do they shade and screen the soil, but, according to some, they directly absorb malaria. However that may be (I do not myself believe it), they undoubtedly intercept the poison, and thus mechanically act as preventive agents. In planting such belts of trees, regard should be had to malaria-producing localities and the direction of the prevailing winds; for if trees are planted in a wrong position they may guide malaria into dwellings and cities instead of warding it off. Of suitable trees there is no lack in the East. The tall, stately forest trees with dense foliage are undoubtedly the best. Those technically known in forestry as “the light-demanding” species are unsuitable. Their thin crowns have a tendency to open out, allowing the light to penetrate very readily to the soil, and intercepting only a fractional part of the rain. Typical trees of this kind are the various species of *Dalbergia*, acacia, palms, and many others of the most valuable Eastern forms. The trees chosen should be of what is known as the “shade-bearing” species, with dense crowns, which effectually screen from malaria-laden winds, intercept a large proportion of the rainfall, and completely protect the earth from the sun.

In this shade-bearing category there is a very large number of majestic trees, valuable alike for beauty and shade, for timber, fruit, and other economic products. I may instance the *Ficus Indica* (*Banyan*), the *Ficus religiosa* (*Peepul*); and, amongst fruit-trees, the noble mango and others of the *Anacardiaceæ*.

In this connection I must refer to the *Eucalyptus* (*globulus*, *serratifolia*, and other varieties), which has been supposed to exercise a specially beneficial effect in malarious lands by its specific action on the soil, and also by the exhalations which emanate from it. It has been tried and found wanting. It has no more influence *per se* on malaria-production than another plant, the common sunflower (*Helianthus*), for which large anti-malarial powers were claimed at one time. In Australia, the natural habitat of the eucalyptus, malaria prevails extensively—at all events in the centre of the island, and in the northern portions, as proved by Professor Liversedge of Sydney (*Lancet*, vol. ii., 1884, p. 797). Professor Tommasi-Crudeli shows that, in the Roman Campagna, at the Tre Fontane, where the eucalyptus was extensively grown, there was a singularly bad outbreak of malarial fever in 1882, while the surrounding villages were free from disease (*Lancet*, vol. ii., 1884, p. 797). The fact appears to be that, as the tree will not grow in a watery soil, an elaborate system of drainage has been found necessary, which would have had just as great an effect without any eucalyptus at all. In India the tree takes kindly to the soil, and is largely grown. It is ornamental, and its timber is hard and valuable, but it affords no protection against malaria. It is essentially a

"light-demander," and its thin crown gives shelter neither to man nor beast nor soil, and is as useless in this respect as the poplar.

But there is one plant of exceptional value, which has not hitherto received notice. I am, I fancy, the first to draw attention to its unique capabilities in the reclamation of malarious lands. I refer to the plantain tree, the banana, as it is called in the New World—*Musa paradisiaca* (plantain), *M. sapientum* (banana), and *M. Cavendishii*. It is indigenous in all tropical countries, and is so rapid in its growth, that it arrives at perfection in a few months. Its cool, deep green leaves are a most refreshing sight in the hot weather; it is a graceful plant, and with its flower and fruit and leaf forms one of the most beautiful objects in a tropical land. Its fruit and fibre are of very high economic value. It grows in dense clumps on almost any soil, and needs neither clearing, weeding, manuring, nor attention of any sort. Once planted, it continues to propagate itself without any attention; it is subject neither to blight nor disease. The special value of the banana in malarious countries is due to its immense capacity for absorbing water. It can be planted in the most waterlogged soil, which it effectually drains. When it dies, inasmuch as most of its bulk is nothing but water, it rapidly dries in the powerful sun, and the dry *débris* enriches the soil without the concomitant evils and noisome odours that arise from the decay of other vegetable matter. I have yet to make a further and more detailed series of observations and experiments before I can formulate definite propositions and give statistics concerning it.

Personal safeguards must be adapted to the peculiar circumstances of each case. In addition to a proper diet, avoidance of exposure to heat and cold, especially when fatigued or in need of food, and the avoidance of infection by a due regard to the seasons and the factors that go to the production of malaria, suitable clothing must be worn: chill is the greatest enemy of health in hot countries, and therefore it is important always to wear flannel or woollen clothes next the skin, and to use sufficient covering at night. The danger of malarial infection may also be diminished by giving due consideration to the prevailing winds, and making encampments to the windward of malarious spots, or screened from them by a belt of trees or expanse of water. Double-walled tents confer great protection, as also mosquito-netting, and the habit, universal amongst the natives of India but not possible to us, of sleeping with the face and head quite covered by the bed-clothes. All water used for drinking purposes, and also milk, should be boiled. Coffee used habitually has a decidedly prophylactic effect, and so, I am inclined to think, has tobacco. The smoker creates around him an artificial atmosphere, warm, dry, and not easily penetrated by unwholesome smells. Moreover, the practice of smoking, when moderately indulged in, soothes and tranquillises the nerves, producing a state of mind in which the person is less predisposed to contract disease, helps to conserve nerve energy, and discourages the attacks of mosquitos.

More direct methods of *prophylaxis* are to be found in the administration of various drugs. According to the views of some, the production of malaria can never be satisfactorily controlled by us, and the victory can

only be won by rendering the system of those exposed to the infection impregnable to its attacks. This end it is sought to attain by the systematic use of anti-periodics. Quinine may be regularly taken with advantage at all times in tropical lands, and it ought to be taken when malaria is rife. Crudeli prefers arsenic, but my own experience is that this drug is uncertain in its action and apt to cause gastric disturbance in the weak, anæmic, and ill-fed. On account of its active properties, its administration has proved to me to be an anxious matter. It is not possible to trust arsenic in the hands of natives, whose ideas of medicine are of the haziest description, and who are quite capable of poisoning the patient through ignorance.

SOME ANCIENT LANDMARKS OF MID-LOTHIAN.

(*With Map.*)

By HENRY M. CADELL, of Grange, B.Sc., F.R.S.E., etc.

THE close connection between geography and geology has often been insisted on in the pages of the *Scottish Geographical Magazine*, and perhaps one of the most interesting examples of this relationship is to be found at our very doors, in the midst of the hills and dales of the Modern Athens. The oldest reliable map of Mid-Lothian seems to be that of Timothy Pont, published during the reign of James VI., about 270 years ago. Since that time the face of the country has undergone many alterations. Wide expanses of peat-moss have been reclaimed, forests have been cleared away, and barren moorlands have been drained and converted into smiling meadows or tracts of rich agricultural land.

The time of which I wish now to speak, however, goes much further back than the Union of the Crowns. It even antedates the period of the Roman invasion, and the formation of the 25-foot beach which indicates the last upheaval of the land or retreat of the sea. The population of Scotland was then insignificant, and our savage ancestors were too few and too ignorant of the arts of peace to exert any important influence on the external appearance of Caledonia, the greater part of which remained a land of brown heath and shaggy wood until a much later period. All the changes that then took place were brought about by the slow agencies of Nature that have, ever since time began, continued to wear down, level up, and smooth over the natural roughnesses of the rocky crust we live on.

Could one of the old residents of 2000 years ago return and give us the benefit of his impressions about the principal changes in the face of the Edinburgh district since his day, he would no doubt, in the first place, note the disappearance of several conspicuous sheets of water from the neighbourhood. He would next sigh for the ancient forest of Drumsheugh, where he was wont to chase the wild boar, deer, and wolf, and would