MALARIA AND THE OPENING-UP OF CENTRAL AFRICA

IN his inaugural address to the University College of Rhodesia and Nyasaland, Prof. Michael Gelfand took the opportunity to review the part which malaria played in delaying the opening-up of Central Africa to European traders and settlers[1]. His original paper is illustrated with reproductions of some fine contemporary pictures which add to the interest of the text.

The earliest in the field were the Portuguese, who were setting up trading posts along the west coast of Africa as early as 1443. Somewhat later they were establishing footholds along the east coast too, but the 'Angel of Death' effectively blocked their penetration into the interior. When quinine became available, the Portuguese took to it more readily than the British and put it to more effective use. Its introduction, although spread over a longer period of time, "had an impact on medicine similar to that of antibiotics to-day".

The legend that cinchona bark was introduced to Europe by the Countess of Chinchon, wife of the Viceroy of Peru, has been convincingly disproved. What is clear is that Jesuit missionaries were in contact with Indians who were aware of the medical properties of cinchona bark, at Loxa, in Brazil, and in Peru, about the beginning of the seventeenth century. Its first recorded importation into Europe was made by Barnabe de Cobo, after exploring parts of Mexico and Peru in 1632. News of it soon spread from Spain to Italy and the Netherlands, and it was introduced to England by James Thomson of Antwerp in 1650.

In many places its acceptance by doctors was very varied, in part perhaps on religious grounds, but in England, resort to its use was stimulated by some serious epidemics of ague, so that the weekly publication *Mercurius Politicus* could report that, by 1658, the bark was on sale by several London chemists. Its fame was heightened by Robert Talbot, who among many others treated King Charles II and the Dauphin Charles of France. He made a fortune out of its secret use. Sydenham was convinced of its efficacy as a medicine, and administered the powdered bark mixed with red wine. As early as 1659 Willis found that the bark relieved acute attacks of ague, although relapses were common; and it was not until 1768 that James Lind observed that, in cases of fever, the drug was most effective if given early in large doses.

In 1745, Claude Touissant de Cagarage attempted to produce an extract of quinine, as did Bernadino Antonio Gomes, of Lisbon, in 1810. Ten years later, Pierre Joseph Pelletier and Joseph Caventou were the first to isolate two of the four alkaloids in the substance. This discovery so stimulated the demand for cinchona bark that exploitation of the forests of Peru, Ecuador and Bolivia was carried to such an extent that fears arose about their exhaustion; the English and the Dutch took up its cultivation, and by 1862 the Dutch had almost established a monopoly in its supply, mainly based on Java.

In comparison with the Portuguese, the British were slow in making attempts to trade with or settle in Central Africa. One of the earliest schemes for settlement was made by William Bolts; it was sponsored by Maria Theresa of Austria. The expedition set out from Leghorn in 1776. It consisted of 152 Europeans, who set up stations along the Masoomo River, in Delagoa Bay, but malaria soon made its presence felt; local Africans rose against the enfeebled party, which was later attacked by the Portuguese, and within three years the entire scheme had collapsed.

These experiences might be taken as representative of a series of disasters which were to follow. About that time some people thought that the Niger joined up with the Nile, others that it had a confluence with the Gambia River. To explore the Niger, the British African Association sent out a Major Houghton, but he, after travelling through the kingdom of Bambouk, was robbed of his possessions and later died. His task was taken over by a Dr. Mungo Park, who left England with two servants in 1795. He reached the Niger in 1796, followed it for 300 miles, and then, emaciated with fever, returned home.

In 1803 Mungo Park led a fresh expedition. This time he asked for a mosquito net and two pairs of trousers for each man. The party left England in 1805; and, after having to contend with malaria, dysentery, incessant rain, swollen rivers and mud, they reached the Niger. There they built a schooner, and sailed down the Niger past Timbuktu, after which the boat capsized and all were drowned. Of the 44 Europeans in the expedition, 35 died of malaria.

An expedition financed by the Navy and led by Captain James Kingston Tuckey set out from England in 1816. The party entered the mouth of the Congo, and some members worked their way up the River as far as Soondy Nsanga, 280 miles from Cape Padron, where, stricken by disease, they had to abandon all hope of progressing farther. Of the 44 Europeans in the party, 18 died of malaria. Dr. McKerrow, a member of the team, gave a good description of the symptoms of malaria. He noticed that the men most seriously affected were those who had visited African villages or slept in the open. As a medicine he made some use of cinchona bark, but only as a last resort, and the results were unpromising.

Another expedition, sponsored by the Admiralty, left England in 1822, with the view of exploring the east coast of Africa, Madagascar and parts of Arabia. A small detachment attempted to make its way up the Zambesi, reaching as far as Senna. Of the three Europeans in the group, one had already died, and the other two died on the journey back to their base.

The failure of the Congo expedition, sent out in 1816, intensified the desire to solve the problem of the Niger. In 1822 Hugh Clapperton with two companions set out to cross the desert from Tripoli. They discovered Lake Chad; then Oudney, one of the group, died, leaving Clapperton to struggle as far as Sokoto by way of Kano, whence he was able to return alive.

Clapperton made another attempt in 1825, with five Europeans in the party. From the Bight of Benin, one of the group reached Yaourie before being murdered by his followers. The remainder went on to Jannah, where they were all ill with fever; but against formidable odds, Clapperton reached Katunga, crossed the Niger, and moved on to Kano. Weakened with dysentery and malaria he died at Sokoto, so that, of the Europeans, four died.

At about the same time, a further expedition set out to reach the Niger by way of Tripoli and Timbuktu. It was led by Major Alexander Gordon, who was the first known European to reach Timbuktu, but he was murdered by Arabs soon afterwards. In 1827, a Frenchman, René Caillié, starting from Freetown, reached the Niger and became the second European to see Timbuktu; he succeeded in returning to France alive.

The riddle of the Niger still remained unresolved. To solve it, Richard Lander, who had been a member of Clapperton's expedition, and his brother, John, offered their services to the British Government. They left Portsmouth in 1830, followed Clapperton's route as far as Bussa, and set sail down the Niger with four negroes as a crew. They reached Eboe, near the Atlantic, but were then captured by Ibu traders and held by different people until finally released, when they found their way to the Atlantic along one of the subsidiary channels of the Niger delta. A boat picked them up and took them to Rio de Janeiro before they could return to England. They had been advised to take two to five grains of quinine every six hours.

Interest in the Niger rose still higher. A company at Liverpool financed an expedition which was led by Richard Lander and had the use of three small steam-boats. Special attention was paid to the physique and fitness of the crews. But before the ships reached the Niger, fever began to take its toll. Moving up to Eboe, two of the boats were surrounded by dense vegetation and swamps on either side, and the men were exposed to relentless rain and "torrents of sandflies and mosquitoes".

Further up stream, one of the boats, the *Quorra*, ran aground and remained stuck fast from November until the following March. At the end of March, MacGregor Laird penetrated up stream as far as Fundah, but got no further, and what had been the supply ship, the *Alburkah*, reached Raba and then turned round. At the end of two years, of the total European complement of the three ships, numbering 82, 64 were dead.

By this time the British Navy was active along the west coast of Africa, attempting to suppress the slave trade. Some indication of the health risks to which the crews were exposed is conveyed by the fact that in 1834, of 792 men serving in seven British ships, 204 died. Nevertheless, in 1841 the British Government and members of the public jointly financed the Great Niger Expedition. Three special ships were built, with the *Wilberforce* joining them later. Each boat had a special system of ventilation: during the night as few men as possible were to remain on deck, and when up river, all the white crew had to sleep below. Special clothing was provided, and dry clothing was to be readily available. The men selected were all robust and in the prime of life.

The ships left Woolwich in 1841, and in August, entered the Niger. On September 4 a virulent attack of fever struck the crew of the *Albert*; soon after, the *Soudan* was sent down stream with all the sick. In October the plan to reach Raba was given up. Sickness and deaths continued so that the British Government decided to recall the expedition. Of a total of 145 Europeans, 42 died—almost all of them of malaria.

In his book on this expedition, M'Williams, surgeon of the *Albert*, reported that the practice of blood-letting, which had been the procedure of first choice for almost all the earlier expeditions, was of no value whatsoever, while quinine given at a late stage and in large doses was of some benefit; but he missed the point, which his own records would have shown, that quinine was more effective if given early. He gave details of eight autopsies in each of which he found the gall bladder distended with bile, "the colour and consistence of tar". The colon was generally empty except for "dark pultaceous matter viscid and tenacious".

By this time it was obvious that Africans were much less susceptible to malaria than Europeans, although these too became more resistant if they lived in the country for long periods. This realization, along with a better appreciation of the value of quinine, marked the turning-point in the opening-up of Central Africa. Quinine had been put to medicinal use in the Navy by Sir William Burnett, although it was not given a fair trial. But Alexander Bryson, who was later to become Director General of the Naval Medical Service, recommended that it should be used as a prophylactic and administered to all members of crews on going ashore and on their return, as well as to those who remained on board in swampy places.

With considerations like these in mind, a new vessel, the *Pleiad*, set sail from Plymouth in 1854, under the command of Mr. Beecroft—later succeeded by Dr. William Blaikie. With 12 Europeans and 53 coloured men on board, it entered the mouth of the Niger and travelled as far as Tshomo; scurvy broke out among the crew, yet although the Europeans were subject to great fatigue and went ashore in unhealthy places, while some of them slept on deck, none of them died. They took three to four grains of quinine every morning, and sometimes in the afternoon.

At this stage David Livingstone came into the picture. It was through reading M'Williams's account of the Niger expedition that he devised his famous pill, consisting of quinine and purgatives. That was in 1850. With it he first treated an English party and members of his own family. His procedure was to give doses large and early; by means of it he was able to cross Africa from coast to coast. His confidence in the pill was so great that he severed connexion with the London Missionary Society, so that he could operate on a wider scale.

By then a national hero, Livingstone had no difficulty in persuading the Foreign Office to sponsor an expedition to ascend the Zambesi as far as Chobe and plant a mission somewhere near the Batoka plateau. When the party reached Africa the members took two grains of quinine every day. Livingstone doubted if that was enough, but he felt that he could stave off serious attacks of fever by extra doses. Altogether, at first things went fairly well in spite of personal dissensions, and in spite of the fact that with a good deal of malaria about, some individuals became more seriously affected. Livingstone also believed in the therapeutic value of physical exertion.

In April 1859, he discovered the Shire Highlands, and in September, Lake Nyasa. Soon afterwards he heard of the fate of the Helmore-Price expedition to Linyanti—an 'unhealthy place'. There was no medically trained person in the group, and out of nine Europeans, six lost their lives.

Further experience of malaria, to which Europeans made a varying response, induced Livingstone to abandon the prophylactic use of quinine for a time. He ran into difficulties over the U.M.C.A. Mission at Magomero, and a series of disasters followed, including the death of Bishop Mackenzie, who lost his supply of quinine when a boat capsized. Worse was to follow: Livingstone's wife died of malaria; the Mission at Magomero, which had been moved to Chibisa, had to be closed down, and he was recalled to England.

The two doctors, John Kirk and Charles Meller, now with extensive experience of malaria, realized that the disease was not so simple as Livingstone had imagined. They identified the dysenteric kind called 'blackwater fever'. Meller distinguished the asthenic and hepatic forms, and experience convinced him of the prophylactic value of quinine, with doses of up to five grains taken daily.

The next steps in the conquest of malaria are more widely known. In 1880, Laveran, a French Army doctor, discovered the cyst-like bodies of the protozoon in the red corpuscles of human blood. This observation was only slowly taken up, but it was confirmed by Marchiafava in 1884; and in 1889, the tertian, quartan and malignant types of the disease were distinguished. Following the discoveries of Manson and Theobald Smith, that insects can act as vectors of disease, on Manson's suggestion, Ross, a British Army doctor, started work in India, and in 1897 found the oocyst in the outer wall of a mosquito's stomach. He worked out the life-cycle of the avian type of the plasmodium in the following year.

Up to 1914, quinine was the only drug known to be effective against *Plasmodium falciparum*, *P. vivax* and *P. malariae*, but not against the gametocytes. The outbreak of the First World War stimulated the search for other preventatives, particularly in Germany where supplies of quinine might be cut off. An observation by Guttmann and Ehrlich, in 1891, that methylene blue had some action against the plasmodium served as a starting-point for Schulemann, who after a series of trials synthesized plasmoquin in 1925, the first artificial anti-malarial.

The discovery of atebrin soon followed. This proved to be a valuable drug for prophylactic use in the Second World War. Still more potent drugs, chloroquine and amodiaquine, were isolated shortly afterwards. These two are excellent, having a complete prophylactic action against almost all forms of malaria, while producing no side-effects. Two further anti-malarials to be discovered were proguanil and pyrimethamine ('Daraprim'), the latter being particularly long-lasting. It was discovered by George Hitching of the Burroughs Wellcome Laboratories.

The conquest of malaria has also been greatly assisted through the use of insecticides, such as pyrethrum, Paris green, benzene hexachloride (BHC) and DDT. In the case of some of these there was long delay between their first discovery and exploitation. BHC, for example, was isolated by Faraday in 1825, yet its insecticidal properties were only discovered in the United States in 1933; and a German chemist, Zeidler, synthesized DDT in 1874, yet its properties as an insecticide were first noticed by Paul Müller in the Geigy Laboratories, in Basle, in 1939. The Second World War did a great deal to stimulate the production and exploitation of these compounds. As an example of insecticidal potency, one might mention BHC, which six months after application on mud walls is capable of killing 80 per cent of *Anopheles gambiae*.

Taken together, all these developments have completely transformed the situation in relation to the conquest of malaria. In Nyasaland, for example, as late as 1897, the death rate among European settlers averaged between 9 and 10 per cent, mainly from fever, in a young population. In Northern Rhodesia, during 1907–08, the death rate from malaria and blackwater fever combined was 30·4 per 1,000; in 1925, even before the aforementioned developments, it had fallen to 2·8.

Such results can be compared with those associated with the construction of the Kariba Dam, which was started in 1956 and completed by 1960. Not once was work held up or even interrupted because of disease. This huge undertaking involved the importation of enormous numbers of African workers from many parts of the country and the employment of many Europeans who had not previously built up any immunity through exposure to malaria. For health and comfort, the living quarters were placed on high ground. All workers were informed about the dangers of heat stroke, and employers were encouraged to allow their workers a period for acclimatization. A survey of the locality showed a spleen rate of 80 per cent, and a parasite rate of more than 30 per cent among the original, local community. All the interior walls of dwellings were sprayed with BHC, and this procedure was repeated three times a year.

As a preliminary measure, an attack was made against mosquito breeding-places through spraying with 'High Spread Malariol' (Shell). Survey counts showed that the operation was effective, so that there was no need to repeat it later. All workers were required to take the prophylactic drug with which they were provided—at first, 0·4 g of camoquin weekly for the Europeans, and 100 mg of mepacrin for the Africans. Later, daraprim was substituted at the rate of 25 mg each per week.

All windows of the European houses were screened, and this helped to keep away millions of other insects as well as mosquitoes. As a consequence, there was not one death from malaria among Europeans living on the site during the first two years. There were two deaths, however, of men living in temporary camps outside the recognized limits, and nearly all the European cases of fever gave a history of irregular prophylaxis, or fishing or hunting at night beyond the controlled area.

These results show that apart from human factors, in Central Africa the conquest of malaria is now almost complete. They also show that in Africa it is a mistake to think of medicine in terms of individual territories.

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[1] Gelfand, M., *Rivers of Death* (Supplement to *The Central African Journal of Medicine*, **11**, No. 8; August, 1965).

APPLIED SCIENCE IN THE SCHOOLS

In recent years a recurrent theme in discussions of science teaching has been the inability of courses in applied science and engineering at universities to attract the best students. This has led to a good deal of self-analysis and exposition of their aims by engineers, and to attempts to acquaint science and careers masters with the nature and purposes of these courses. More fundamental questions are those concerned with changes in the nature of school science teaching itself, and some of the great interest in the new pure science syllabuses of the past few years has now shifted to the possible introduction of applied science courses at school level. This concern led the Institution of Mechanical Engineers* to ask Mr. G. T. Page to assemble a report on the present situation in schools, and in a very short time he produced a mass of information and ideas, obtained both by direct visits and by a postal survey, collated, compared and summarized into an urgent, highly relevant volume.

A conference in October, to discuss this report, showed a very high degree of interest in the whole subject and also produced very complimentary estimates of the report itself, and it is certain that it is at present exercising headmasters and many educational authorities throughout the country. Mr. Page labels his book as descriptive rather than prescriptive, and a large part of the 328 pages is taken up with detail of what is done in a number of schools, both in terms of actual teaching of applied science and 'application-conscious' teaching of physics and chemistry, with syllabuses, details of projects, costing and much more important information, both in the text and in appendixes. A lot of space is devoted to the best known experiments in the field, such as the Technical Activities Centre at Sevenoaks School, the examined project work at Dauntsey's School, and the sixth-form courses in applied science such as that at Ealing Grammar School. However, the report is much better regarded as a digest of many different opinions about, and aspects of, the whole subject. There are, for example, chapters on "Engineers as Teachers" and "Workshop and Laboratory Technical Assistance", and a provocative section called "What the Universities Really Think", in which the widely different views of many authorities are contrasted. Throughout, one finds figures, data of all kinds, and tables and photographs of typical laboratories as a basis for further discussion and investigation. In the final chapter, thirty-one suggestions of possible definite actions are made, ranging from joint industrial/school associations to long-term curriculum research. Two particularly interesting lines of argument emerge. One is that it was everywhere insisted by schools who have begun applied science courses that this was done for educational reasons rather than vocational reasons (although some comment in Scotland was less altruistic). The Crowther Report suggested that for many schoolchildren, the 'alternative road' to interest in scientific and technological matters is the most attractive one, and in many cases it has been stated that applied science has been introduced to make school science in some way less dull. Generally, it is true to say that there has been in the past, and still is, in school courses, a pre-

* The Institution of Mechanical Engineers: *Engineering Among the Schools: Activities in Applied Science and Engineering—a Survey of 290 Schools.* Pp. 328. (London: The Institution of Mechanical Engineers, 1965.)