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SIR RONALD ROSS AND THE SIGNIFICANCE OF HIS WORK

IT WAS my pleasure in January, 1927, to be present at the unveiling of a bronze tablet on a gateway in front of the Presidency General Hospital in Calcutta, leading to the unpretentious little brick building in the hospital compound which Sir Ronald Ross used as a laboratory twenty-nine years earlier. That spot deserves to rank among the first in the world in historic interest, yet I had lived in Calcutta for almost three years and had passed that very gateway hundreds of times, without knowing of its existence. In an address made at the time, Colonel Megaw, then Director of the School of Tropical Medicine in Calcutta, remarked that it was astonishing that so few of the inhabitants of Calcutta knew of the existence of the little laboratory where one of the greatest discoveries in the history of the world was made. He added that although over twenty-eight years had passed, we had only begun to scratch the surface of the vast mine of wealth which that discovery had placed in our hands. "A prophet," said Col. Megaw, "is not without honor save in his own country. Sir Ronald's offense did not consist merely in being a prophet; he added to it by being a poet and a scientist, and so trebly earned the indifference with which his great work was received in India." This same Sir Ronald Ross, at the age of seventy-five, died at his modest home in Putney, England, barely six months ago. It is appropriate therefore that we should devote an hour here to a review of

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this great man's life and work, and to consideration of the importance and significance of his achievements.

The importance I have attached to Sir Ronald Ross's work may appear exaggerated to some of us who have lived all our lives in places where malaria is little more than a name. But in India alone there are estimated to be well over a million deaths a year from malaria, a greater number than was caused by the great European War in the first two years of its existence. Malaria is endemic over about one-third of the surface of the earth. Vast areas in Asia, Africa, and tropical America are scourged by it, and even large parts of Southern Europe and Southern United States suffer severely. According to a recent estimate 800,000,000 people in the world suffer from malaria. Can anyone even dimly visualize the amount of suffering and sorrow and economic loss that that entails? Since the bulk of it occurs among already impoverished people, it means hunger, and famine, malnutrition of children, and high infant mortality. Dr. Balfour has estimated the direct economic loss to the British Empire, due to illness and mortality from malaria, to be in the neighborhood of two hundred million dollars annually. In our own Southern States an estimate of a million cases of malaria a year is conservative. Some years ago Dr. L. O. Howard, for many years the Chief of the U. S. Bureau of Entomology, estimated the annual financial loss in the United States from malaria to be not less than one hundred million dollars.

If malaria means that much to the human race, it must be admitted that a discovery which makes possible the control of it must also be considered of vast importance, and that is what Ross's discovery did. Of course Ross's "discovery" was by no means comparable with striking oil when digging a cesspool, or stumbling over a treasure chest when strolling in the moonlight with a sweetheart. In the introduction to

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his *Memoirs* Ross quotes a friend of his who epitomized the popular notion of scientific research by picturing a scientist consulting his watch and exclaiming "Ha, half an hour to spare before dinner; I will step down to my laboratory and make a discovery." Ross reminds us that our books of science are records of results rather than of the sacred passion for discovery which leads to them. "Yet," he says, "many discoveries have really been the climax of an intense drama, full of hopes and despairs, visions seen in darkness, many failures, and a final triumph: in which the protagonists are man and nature, and the issue a decision for all the ages." Ross is thus describing his own discovery, which came after years of toil, after hundreds of discouraging failures, and after repeated heart-breaking interruptions and exasperating interferences. But even those years of persistent labor, crowned at last by successful observations and experiments, were only, as it were, the turning of a key in the lock. Prior to this it was necessary to find the way to the door where the lock was situated, and to be in possession of a key that would fit the lock. Hundreds of observations, speculations, and collateral discoveries were necessary to point the way and clear the road. Before telling you of Ross's work I would like to give you a brief outline of the earlier history of malaria.

This disease, which is now recognized as the most important one with which the human race has to contend, not even excepting tuberculosis or hookworm, was well known to medical writers among the ancients. They, and practically everyone else up to the close of the nineteenth century, were well aware of the association of malaria with low marshy places. As its name implies, it was believed to be due to some poisonous quality of the air arising from such places, to which the name miasma was given. Many of the attributes,

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habitats and vagaries of this deadly miasma had been worked out with surprising accuracy.

We must not suppose for a moment that the possible instrumentality of mosquitoes in the spread of malaria had never occurred to any of the millions of people who through the centuries have suffered from and struggled with malaria. It is by no means a rare occurrence for popular beliefs which are long ridiculed or ignored by science, eventually to be proved correct. Thus it has been with the mosquito theory of malaria transmission.

It was in 1880 that the scientific study of malaria really began, for it was in that year that Laveran, a French army surgeon in Algeria, observed the minute parasites in the red blood corpuscles of malaria patients, which he recognized as the cause of the disease. There followed a differentiation of the several different species, and a study of the cycle of development which takes place in the human body, each recurring paroxysm of chills and fever being found to be coincident with the liberation of a new brood of young parasites from the blood corpuscles in which they had been developing for forty-eight or seventy-two hours, according to the variety of malaria. Laveran himself expressed belief in the mosquito transmission of the disease in 1884; the great German bacteriologist, Koch, did likewise in 1892; and in 1894 Dr. Patrick Manson, who had distinguished himself in the study of tropical diseases in China, also expressed belief in the mosquito theory.

Besides these researches, speculations and observations with respect to malaria itself, there were certain other discoveries which must be recognized as having contributed, if only as precedents or suggestions, to the elucidation of the malaria problem. One of these was the discovery by Patrick Manson, in 1878 and 1879, that mosquitoes were involved

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in the transmission of filariæ, which are small worm parasites living in the lymph glands and ducts of human beings. Had Manson completed his observations on the life cycle of filariæ he might have made a better guess than he did with respect to the mechanism of malaria transmission, and have saved Ross many an hour of hard work.

Another piece of work which influenced research on malaria was that of Theobald Smith and Kilborne on the transmission of Texas Fever of cattle by ticks. These American scientists did what Manson might have done, but didn't; they showed, in 1893, exactly how an insect served in the transmission of a blood disease from one animal to another. But in this case the transmission takes place through the offspring of the infected ticks, the germ of the disease being passed on to them, through the eggs, from their infected mothers. Although this work of Smith and Kilborne served as a very suggestive precedent for the mosquito transmission of malaria, it also was the cause of many a wasted bead of sweat from honest labor in its suggestion of a possible hereditary transmission in the case of the mosquitoes.

Now, although Manson gets a great deal of credit for formulating the theory that mosquitoes carry malaria, as we have seen he was by no means the first to lay his bet on the right number, and as a matter of fact Manson's guess wasn't as near right as some of the earlier guesses, for he thought that the malaria parasites, after being sucked into the body of the mosquito, turned into resistant spores which, when the mosquito died and fell into water, survived in this water until they eventually found their way into another human being's stomach. The important thing that distinguished Manson's theorizing from that of others was the fact that he theorized in the ear of an adoring disciple who was violently enthusiastic by nature, was endowed with more than

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usual perseverance, and, being an officer in the Indian Medical Service, was in a position to do some experimental work on the subject. That man was Major Ronald Ross. There is no very good reason why Patrick Manson could not himself have tested his mosquito theory in London, where he was in contact with plenty of malaria cases returning from the seven seas, but he had a pleasant and growing practice in London, and apparently preferred to inspire someone else to do the work for him.

Now let us go back and see what manner of man this was who was undertaking to prove Manson's theory. Born in a hill station in India on Friday, May 13th, 1857, the son of a British army officer, Ronald Ross spent the first eight years of his life in India and was shipped back to England for the sake of his health and education. However, Ross himself remarks in his *Memoirs* that the money his parents spent on his education was largely wasted. His father chose medicine as a profession for him, and he finally resigned himself to his father's wishes, although he claims to have had no predilection for medicine and more or less looked down upon it. He burned the midnight oil composing music and writing poetry and epic dramas instead of studying anatomy, and consequently, although he succeeded in passing an examination for membership in the Royal College of Surgeons after only three days of feverish study, he failed to pass the easiest medical qualification he could try for, having begun studying for it on the morning of the examination. After that he spent a year as a surgeon on a transatlantic vessel but spent his time mostly in studying life and writing dramas and poetry about it. To make a long story short, he finally passed his examinations for the Indian Medical Service, near the bottom of the list, and spent the next thirteen years of his life in various Indian cantonments,

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hospitals, and military posts as a medical officer, fumbling feebly at his professional work, but laboring fervently and feverishly, even to the point of injuring his health, first at poetry and drama, then at complicated mathematical propositions and theories, with the aid of which he attempted to work out a theory of the universe, and then back to literature again.

Although Ross never became preëminent either in literature or mathematics, his achievements in both fields are far from mediocre.

It was not until 1890 that Ross finally determined actually to labor at his profession; after reading some medical books and journals he found he could not obtain much help from them so, as he had done in other lines, he energetically set out to do things for himself. He decided that malaria was a sort of intestinal disturbance and wrote four papers on the subject. He decided that Laveran was all wrong about the malarial parasites, and also that the miasma theory was wrong, and wrote four more papers exposing these errors. But he soon drifted back into literature and mathematics and decided that when he got his pension in 1897 he would adopt literature as a profession.

In 1894 Ross got a year's furlough to England, in the course of which he met Dr. Manson and had his exuberant enthusiasm and energy directed towards malaria and mosquitoes instead of meters and mathematics. After his arrival at his station in Secunderabad in Southern India he went at his task with wild excitement and almost frenzied enthusiasm. He knew nothing about the kinds of mosquitoes, or how to take care of them, or how to handle them, or what to look for in them. As a consequence he worked blindly and made many unnecessary errors, but he stayed with the job. He differentiated various kinds of mosquitoes according to a

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system of his own, he learned how to breed and care for them, he found out how to make them bite even though, as he expressed it, they were as stubborn as mules, and he became expert in dissection and microscopic examination. In examining mosquitoes for possible developmental stages of malaria parasites he says he searched every micron with the same passion and care as one would search some vast ruined palace for a little hidden treasure. After having examined many hundreds in this way without result, and with no assurance that there was anything to find, a lesser man's passion and care would have gotten frayed at the edges before the search was finally rewarded. He kept Dr. Manson informed of all his doings, and in return got advice and directions and encouragement from his hero. Manson told him to consider himself a Sir Galahad looking for the Holy Grail.

Three long hot months he spent in feeding mosquitoes on malarial blood and endeavoring to find out what happened to them in the mosquito, but alas! he was using kinds of mosquitoes which are not involved in human malaria and made little progress. Following Manson's suggestion he let mosquitoes which had fed on malarial blood die in a little bottle of water, and then gave some natives backsheesh to drink the water. Eleven days later one of the natives got sick and had fever for three days, but there were no malaria parasites in his blood, so he rightly concluded that this was a false alarm. Finally, after failing to follow the so-called flagellated spores into the tissues of the mosquito, or anywhere else, he decided to keep his insects alive for a few days after feeding on his patients and then see what there might be to see. This time he was sidetracked by another protozoan parasite of mosquitoes. He spent long weeks studying this in the hope of connecting it with malaria, but without success. Then came an interruption while he was delegated to control

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an outbreak of cholera in Bangalore. In 1896 he began to form some notions of his own, and wrote Manson that the belief was growing on him that the mosquitoes transmitted malaria by their bites. He did some experiments to find out, but as he only kept his mosquitoes a few days after feeding, the results were negative. Finally in 1897 he got hold of some brown dapple-winged mosquitoes, and on the 20th of August of that year, when about to give up his labors for the day early on a hot muggy afternoon, he decided to examine one more mosquito. This time, to use his own words, the Angel of Fate fortunately laid his hand on his head, and he discovered in this mosquito some cells which he recognized at once as developmental stages of the malaria parasite. That evening he wrote some more verses to his poem "In Exile," which, as amended a few days later, read as follows :

This day relenting God
Hath placed within my hand
A wondrous thing; and God
Be praised. At His command,

Seeking His secret deeds
With tears and toiling breath,
I find thy cunning seeds,
O million-murdering Death.

I know this little thing
A myriad men will save.
O Death, where is thy sting?
Thy victory, O Grave?

During the later years of his life Ross always celebrated the 20th of August as the anniversary of "Mosquito Day."

After another interruption Ross resumed his work on malaria in Calcutta in February, 1898. Failing to make any progress on human malaria, he began working on bird malaria; by the latter part of April he had proved beyond

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question that the malaria parasites undergo development in the mosquitoes, and by the early part of July he made an even more important discovery:—by tracing the development in the bodies of infected mosquitoes he discovered the production of thousands of spore-like bodies which invaded the salivary glands of the mosquito and were injected with its bite, from which he deduced, rather hesitantly and almost apologetically, since it was contrary to Manson's ideas, that malaria was transmitted to birds by the bites of mosquitoes, and at once he proved it by actually infecting healthy birds by the bites of his infected mosquitoes. Few seemed to doubt but that what Ross had proved for bird malaria would also be applicable to human malaria, although Manson himself remarked, "One can object that the facts determined for birds do not hold, necessarily, for men." Subsequent work proved that Ross's work on bird malaria does hold for human malaria as well, only in different kinds of mosquitoes. But unfortunately Ross was not the one to put this crowning touch to the work. Dame Fortune, as Ross writes in his *Memoirs*, did nothing but buffet him about for the remainder of his time in India. First she sent him the so-called "black spores" to worry him for weeks, then she gave him one of the few species of *Anopheles* which does not carry malaria. She continued a plague scare which aroused popular prejudice against any experimental work on human beings. She made the Royal Society refuse to send him help. She instigated Surgeon General Harvey to interrupt his work for months on the kala-azar inquiry in Assam; and lastly, to quote Ross, "She arranged that some ingenious Italian gentlemen should pirate most of my results in the interval."

Demonstration of the fact that malaria is transmitted only by the bite of certain kinds of mosquitoes, of course suggested at once the possibility of control if not actual eradica-

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tion of the disease by attack on *Anopheles* mosquitoes. On his way home from India in 1899 Ross meditated over the practical application of his work. "In two years," he said to himself, "we shall stamp malaria out of every city and large town in the tropics, at least if they possess sanitary departments as in British possessions." Wherever there was a white man or trained inspector to command, and a few coolies to work, it could be done. This, Ross asserts, was not the dream of a visionary, but a carefully reasoned statement of a man who knew from experience with other sanitary projects what he was talking about.

It was not long before it was abundantly demonstrated that Ross was right in believing that the control of malaria could be accomplished, but it has also been demonstrated that he was wrong in believing that it would be. It is a project which costs money, requires interest on the part of governments, and a popular demand. Where these requirements have been found, malaria has either been abolished or reduced to a small fraction of what it once was.

The first anti-malaria campaign was begun in Havana in 1901. There were no precedents, no handed-down information, no previous successes or failures to lead the way, but Colonel, later General, Gorgas, who conducted the campaign, was a genius in sanitation, and he made a triumphant clean-up of malaria in that Cuban city. From 1890 to 1900, in a population of 350,000, there were 5,643 deaths from malaria; from 1900 to 1910 there were 444 deaths in a much larger population.

Meanwhile Ross himself was doing his utmost to get the British or Colonial Governments to act, but without success. Finally, in 1901, Ross organized an expedition of his own to West Africa, financed by private funds of a backer, to

demonstrate to a skeptical world the possibility of actually controlling mosquitoes at a reasonable cost. This expedition was successful, and was followed soon after by an equally successful demonstration at Ismailia on the Suez Canal.

But the most striking example of what can be done in the control of mosquito-borne disease is the transformation of the Canal Zone in Panama from a White Man's Graveyard to one of the healthiest localities in the world. The work in Panama has been described by a great British sanitarian who did a similar job in Malaya, as the greatest sanitary achievement the world has ever seen. The French attempt to build a canal across Panama was wrecked by malaria and yellow fever, both mosquito-borne diseases; the graves of fifty thousand laborers were dug, but no Panama canal. Shipload after shipload of laborers, engineers, nurses, and doctors were sent to this pest hole, the lives of the majority to be snuffed out in a few weeks or months. One vessel is reported to have brought over eighteen young French engineers, all but one of whom died of yellow fever within a month. In 1904 the Americans bought the French rights and set to work, with Colonel W. C. Gorgas as Chief Sanitary Officer. As a result of his application of the recently acquired knowledge concerning yellow fever and malaria, the last case of yellow fever ever to develop in Panama occurred in September, 1905. In 1906 the average rate of hospital admissions for malaria each month was 6.83% of the canal employees. Year by year it dropped until in 1913 it was 0.64% per month, less than one-tenth what it had been seven years earlier. Colonel Gorgas himself wrote to Ronald Ross the following words: "It seems to me not extreme therefore, to say that it was your discovery of this fact (the transmission of malaria by the bites of mosquitoes) that enabled us to

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build the Canal on the Isthmus of Panama." It is that same discovery which will some day bring about the conquest of the tropics, the prevention of millions of human deaths per year, and the elimination of an unimaginable amount of human suffering.

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