in this one respect, Greek tradition and ceremonial was a cause of the most gross inhumanity. The unhappy visitant whose vital powers were finally declining was received and domiciled in the abaton, but when he failed to improve and was seen by priests and attendants to be obviously dying, instead of being tenderly nursed and soothed, he was removed from his couch, dragged across the precinct to the nearest gate, expelled, and left to die on the hillside unhelped and untended. Asklepios had rejected him, and no priest or minister of the god must defile himself by any dealings with death. One cannot but hope that the sympathy and humanity which exists naturally in the hearts of most men and of all women found some means of helping these unhappy beings, and that when death seemed probable such sufferers were conveyed to a hostel outside the precinct, and allowed to die in peace there. A like superstition existed regarding birth. Many a poor woman in the later months of pregnancy, who had been hoping for relief from some ordinary ailment, was suddenly and mercilessly expelled from the precinct just when she needed help and comfort most. Not until the time of the Antonines was any definite provision made for these two classes of sufferers. Either Antoninus Pius or Marcus Aurelius erected a home for the dying, and a sort of maternity hospital. Doubtless some of the ruins dating from the Roman period, which are at present unidentified, subserved these two purposes.

Among the hundreds of inscriptions found I have thus far only mentioned one class—namely, those referring to cures. There are, in addition, no fewer than thirteen other kinds of inscriptions. For example, the great poem of Isyllos, describing the genealogy and miracles of Asklepios, written by command of the oracle of Delphi. The Delphic Sybil had a great respect for the god of healing. On another occasion she addresses him in the following flattering terms: "O thou who art born to be the world's great joy." There are numbers of inscriptions relating to the priests, the Pyrophoroi, the Hieromnemes, or in honour of distinguished Greeks or Romans; others contain laws and judicial decrees, or refer to the contests of the stadium; others again give lengthy and minute details concerning the cost of construction of the temples. In the present notice it is useless for me to speak of the numerous votive tablets, as space will not allow me to supply reproductions of more than one of them. Note the group of suppliants, with their children, approaching the god and his attendants, who are all of heroic stature.

Fig. 5.—Suppliants asking help from Asklepios.

Every fourth year a great festival was held at the Hieron, the Megala Asklepieia, at which athletic contests, races, processions, music, plays in the theatre, holy vigils, lasting all night, gorgeous rites, sacrifices, decoration of the temples and precincts, together with feasts, took place. Most probably the priests would arrange for the performance of a few miracles. Other festivals were also held, as the Megala Apolloneia.

Lastly, there is a link which, though of no practical import, is still a genuine historic bond connecting the Hieron of Epi-

daurus with the medicine of western Europe. Three centuries B.C. Rome was visited by dire pestilence. The rulers of Rome, having in vain sought to check it, sought the counsel of the Sybilline books, and were directed to bring Asklepios to Rome from Epidaurus. A galley was sent to the Saronic Gulf, and a mission visited the Hieron, bringing back to the ship one of the sacred serpents. The galley returned, entered the Tiber, approached Rome, and as it touched the insula in the Tiber the sacred serpent at once left the ship and found a refuge on the island. From that moment the plague is said to have rapidly disappeared. In gratitude to the god who was thus visibly among them in the serpent form, the south end of the island was modelled into the shape of part of a great galley of hewn stone. A temple of Æsculapius (as the Romans called him) was built adjacent to it, with portico and abaton. A well existing there became sacred to Æsculapius, and from that day to this the island in the Tiber has, through pagan and Christian times alike, been devoted to the cure and treatment of the sick. The prow of the stone galley still exists, with the effigy of the serpent and remains of the image of Æsculapius. The Church of St. Bartholomew stands on the site of the temple, and on or near the spot where stood the ancient abaton now stands a hospital served by the brotherhood of San Juan de Dios, the benevolent saint of Granada, where the sick folk of Rome are helped and tended; and there, unlike their predecessors of 2,200 years ago, if illness should terminate in death the poor weary souls are kindly and tenderly ministered to by priest, physician, and nurse until they sink into the last sleep.

It is doubtless in consequence of this episode of the founding of a temple of Æsculapius on the island of the Tiber that the staff and serpent of the Epidaurian god have been, and remain to this day the symbol of our profession.

SURGEON-MAJOR RONALD ROSS'S RECENT INVESTIGATIONS ON THE MOSQUITO- MALARIA THEORY.

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READERS of the BRITISH MEDICAL JOURNAL will recollect that in the issue of December 18th, 1897, Surgeon-Major Ronald Ross described certain pigmented cells found imbedded in the stomach wall in two specimens of a peculiar ("dapple-winged") species of mosquito which had fed on a malarial patient whose blood contained the crescent plasmodium. The characters of the pigment in these cells were such that Dr. Thin, Mr. Bland Sutton, and myself concurred with Ross in regarding it as the product of the malaria parasite; but as to whether it belonged to a living parasite, or whether it was simply malarial pigment taken up by certain gastric cells of the insect as a normal physiological operation, the preparations and other evidence before us did not, we concluded, warrant a positive statement.

In a second communication to the JOURNAL of February 26th, 1898, Ross stated that he had subsequently found similar pigmented cells in a third "dapple-winged" mosquito fed on crescent-containing blood; and, also, in a grey or "barred-back" mosquito which had fed on a patient with benign tertian infection. He further pointed out this significant fact—namely, that whereas the pigmented cells were but 7μ in diameter in one of his mosquitos dissected two days after feeding, in another mosquito killed four days after feeding the pigmented cells measured 17μ ; in a third killed five days after feeding they measured 19μ ; and in one killed about a week after feeding they had a diameter of at least 25μ . In other words, these cells exhibited one of the evidences of life-growth.

Prior to these observations Ross had examined hundreds of mosquitos both after feeding on malarial blood and also after feeding on healthy blood; but, although the dissections and microscopic examinations had been carefully conducted, hitherto he had not once encountered any structure at all resembling the pigmented cells in question. The explan-

tion of this appeared to be that his earlier feeding experiments had been made with quite other and, presumably, unsuitable species of mosquito. Hitherto he had not experimented with "dapple-winged" insects fed on crescent blood, nor with "barred-back" insects fed on tertian blood.

These facts gave some grounds for believing that the newly discovered pigmented cells represented a phase in the extracorporeal life of the plasmodium; and, also, that it was not every kind of mosquito that could serve as host to the parasite. Further, they seemed to indicate that whereas the plasmodium of æstivo-autumnal malaria requires one species of mosquito, that of tertian requires another; circumstances which suggested that the parasite of quartan malaria also demands its own special kind of mosquito.

There was one feature in Ross's discovery which did not appear reconcilable with the mosquito-malaria hypothesis for which I was responsible, and by which Ross's investigations had been guided. According to this hypothesis the flagella of the malarial flagellated body are supposed to be the immediate agent by which the tissues of the mosquito are infected. As the flagellum carries no pigment, if the pigmented cells belong to the mosquito, or extracorporeal, phase of the malaria parasite how account for the pigment these cells contain?

It seems to me that MacCallum's recent discoveries in halteridium infection (*Lancet*, November 13th, 1897; *Journal of Experimental Medicine*, January 7th, 1898) have very opportunely supplied the explanation. This observer found that in the case of halteridium, a parasite of birds, strictly analogous to the malaria parasite of man, the function of the flagellum is to impregnate certain free pigmented halteridia spheres. Subsequently the impregnated spheres, apparently in consequence of the entry of the flagella, slowly change shape and become converted into locomotive vermicules in the posterior part of which the characteristic pigment accumulates.

The structure, shape, and behaviour of these travelling pigmented vermicules suggest that their objective is some cell in the stomach wall of the mosquito where they become pigmented bodies corresponding to those described by Ross. Doubtless what holds good for halteridium is equally applicable to the closely allied human plasmodium; indeed, although he has not witnessed the transformation of the plasmodial sphere into the travelling vermicule, MacCallum has actually seen and described its impregnation by the flagellum. There is nothing in MacCallum's discovery, therefore, incompatible with the mosquito-malaria theory; on the contrary, it strongly supports it, supplying the explanation of the presence of pigment in Ross's bodies.

Up to the beginning of this year Ross had pursued his investigations under very unfavourable conditions. Early in the present year, however, the Indian Government, wisely recognising the importance of his labours, transferred him to Calcutta that he might devote himself entirely to malaria studies, and at the same time placed a well-equipped laboratory at his disposal.

Finding that the season of the year was unfavourable for procuring a steady supply of human malaria, Ross turned his attention to the corresponding parasites of birds—to halteridium and especially to proteosoma (Labbé). He very soon found that a certain species of mosquito fed on bird blood containing halteridia, when dissected always exhibited pigmented cells in the stomach wall. Ross, however, devoted himself more particularly to the study of proteosoma of sparrows, larks, and crows. During the last few months he has conducted a series of experiments on this parasite which have yielded results of a highly important character. Indeed, he is now thoroughly convinced that the mosquito-malaria theory is sound, and that he has proved it. In due course the details of his work will appear as a report to the Indian Government. Meanwhile, he has sent me from time to time an account of the progress of his investigations, together with numerous preparations illustrating the various facts described in his letters, and he has now authorised me to state the general drift of his conclusions. These are, in his own words, as follows:

"1. Pigmented cells are found in the stomach wall of grey mosquitos fed on crows, larks, and sparrows with proteosoma.

"2. Pigmented cells are not found in control grey mos-

quitos fed on healthy men, or men with crescent plasmodia, on healthy sparrows, on crows and larks or on crows and pigeons with halteridium.

"3. These pigmented cells are found in the external coat of the stomach, and grow from a size of 6μ in thirty hours to 60μ at six days, and are probably coccidia.

"4. Successive feeds by the same mosquito on the same bird are followed by fresh crops of young coccidia.

"5. Similar pigmented cells have been found in mosquitos fed on human gymnosporidia (Labbé)."

As evidence of the care and scientific precision of Ross's work, I may cite the following experiment. He raised thirty grey mosquitos from a batch of grubs procured at the same time and from the same puddle. Ten of these mosquitos he fed on a sparrow in whose blood proteosoma was exceedingly plentiful; ten he fed on a sparrow in whose blood proteosoma was only moderately abundant; and ten he fed on a sparrow in whose blood he could find no proteosoma. Fifty hours later these thirty mosquitos were dissected and mounted for microscopical examination, and the pigmented cells counted in each mosquito and noted on the label on the slide. The slides were then sent to me to check the enumeration. The following table shows the result:

Enumeration of Pigmented Cells in the Stomach Wall of Mosquitos Fed on Sparrow's Blood.

A.		B.		C.	
Sparrows with severe Proteosoma Infection.		Sparrows with Moderate Proteosoma Infection.		Sparrows with Blood free from Proteosoma.	
Ross.	Manson.	Ross.	Manson.	Ross.	Manson.
25	27	112	173	—	—
109	142	6	33	—	—
15	15	29	78	—	—
125	150	14	57	—	—
162	235	40	74	—	—
15	18	1	17	—	—
78	65	12	31	—	—
9	1	30	26	—	—
445	407	24	40	—	—
25	24	24	42	—	—
100.8	108.4	29.2	57.1	—	—

This is only one of many experiments, all of which go to show that certain phases of the hæmatozoal intracorporeal parasites of man and birds, after entering the stomach of special species of mosquito, pass into the tissues of the stomach wall of the insect (Fig. 1), rapidly increase in size, and probably, towards the termination of the life of the mosquito, sporulate, and leave the capsule which, by that time, has formed around them (Fig. 2).

Although no argument or fact of importance has been advanced against the mosquito-malaria theory, and although it has been approved by some writers of standing, it has nevertheless been looked on askance by not a few. I have been stigmatised as a sort of pathological Jules Verne, and hinted at as being governed by "speculative considerations," and as being "guided by the divining rod of preconceived idea." It seemed to me that the theory I enunciated was the logical outcome of well ascertained facts, and the most likely explanation of the relationship of these facts to each other, and the most promising guide to fresh facts. Despite my critics, I still think that work undertaken with the object of advancing knowledge is most economically expended if directed by "speculative consideration" and "preconceived idea," provided these considerations and ideas are founded on facts, and are compatible with ascertained facts.

The speculation in question has certainly guided Ross to further and important facts, all of which point to the conclusion I ventured to indicate. After three years of incessant labour on the mosquito theory, Ross firmly believes in it, and, if I may be allowed to say so, there is no one with a better right to form, or more capable of forming, a sound opinion on the matter.

My object in making this communication is three-fold. First, again to call the attention of workers on malaria to

this promising field for investigation; secondly, to place on record Ross's claims to priority in discovery; and, lastly, to vindicate myself from the charge of unscientific and unwarrantable speculation.

Fig. 1.—From a preparation of mosquito's stomach dissected thirty hours after the insect had fed on bird's blood containing proteosoma. The pigmented cells evidently lie between the longitudinal muscular fibres which they have to some extent disassociated.

Fig. 2.—Development of the pigmented cell. The figure marked "6th day" is intended to represent what is evidently a capsule from which its contents have escaped.

Doubtless, important practical results will spring from these, at present, purely biological investigations; but before such a practical outcome can be looked for much additional work has to be accomplished. The many species of mosquito in India, and elsewhere throughout the malarial belt, will have to be studied, described, and classified, and their habits and haunts thoroughly ascertained. In addition, the behaviour of each species in respect to human and avian intracorporeal protozoa will have to be determined. This is a work of great magnitude, and far beyond the power of any individual, no matter how diligent, to grapple with successfully. It would be well, therefore, that some plan of collective investigation be instituted in which competent entomologists, protozoologists, and pathologists might co-operate. Working on a well-conceived plan such a body of investigators would rapidly fill in the gaps (Fig. 3) in our knowledge of the extracorporeal life of the malaria parasites, and thereby prepare the way for a well-grounded and scientific prophylaxis for malaria.

The drawings represent (Fig. 2) the evolution of the pigmented cell in proteosoma-fed mosquitos; Fig. 1 the position of those cells among the muscular fibres of the insects' stomach. These were made from Ross's preparations. Fig. 3 is intended to represent more or less diagrammatically what has already been ascertained of the extracorporeal life-history of human and avian gymnosporidia, and to indicate the gaps yet to be filled in.

Dr. George H. F. Nuttall (late Associate in Hygiene

Johns Hopkins University, Baltimore, U.S.A.), Assistant Hygienic Institute, Berlin, has sent me the following note: "I have seen the preparations referred to by Dr. Manson in the foregoing article, and consider that they bear out the interpretation put upon them. It is very important that these most suggestive and valuable observations should be followed up, and every encouragement given to such original investigations."

	Avian		Human		
	Proteosoma	Halteridium	Crescent forming, Tertian	Quartan	
1					Vertebrate or Intracorporeal phase
2					
3					Mosquito phases
4					
5					Gastric tissue phase
6					
7					
8					

Fig. III.

Fig. 3.—Diagram indicating what is now known and what is yet to be ascertained of the mosquito phase of certain human and avian plasmodia. A Quartan parasite. Impregnation of pigmented sphere (a, 3), vermicular (a, 4), and (a, 5, 6, 7, 8) entire gastric tissue phase yet to be ascertained. b. Tertian parasite. Impregnation of pigmented sphere (b, 3), vermicular (b, 4), and conjectured sporulating phase (b, 8) yet to be ascertained. c. Aestivum-autumnal parasite. Vermicular (c, 4) and sporulating phase (c, 8) yet to be ascertained. d. Halteridium. Sporulating phase (d, 8) yet to be ascertained. e. Proteosoma. Impregnation of pigmented sphere (e, 3), vermicular (e, 4), and sporulating (e, 8) phases yet to be ascertained.

I have a letter also dated June 12th, from Professor Laveran, who has received specimens direct from Dr. Ross. In the course of this letter M. Laveran expresses his opinion in words which may be translated as follows: "It appears to me to be undoubted that the elements discovered by Dr. R. Ross in the stomach of mosquitos fed on the blood of birds, the subjects of hæmosporidiosis, are really parasites, and that these parasites represent one of the phases of the evolution of the hæmatozoa. It is probable that it will now be easy to find the extracorporeal form (*la forme de résistance*) of the parasites in external media. The discovery of Dr. Ross appears to me, as to you, to be of very great importance. It is a great step forward in the study of the evolution of the hæmatozoon of birds, and very probably also in that of the hæmatozoon of malaria. I have shown the preparations to M. Metchnikoff, who shares my opinion."