ON A CONVENIENT TERMINOLOGY FOR THE VARIOUS STAGES OF THE MALARIA PARASITE.*

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I HAVE found it necessary in labelling a series of models of the malaria parasite in the Central Hall of the Natural History Museum to use as simple and clear a terminology as possible. I think that this terminology will be found useful by others who are perplexed by such terms as "sporozoites," "blasts," "ookinetes," "schizonts," "amphibionts," and "sporonts"—terms which have their place in schemes dealing with the general morphology and life-history of the group sporozoa, but are not, as experience shows, well suited for immediate use in describing and referring to the stages of the malaria parasite.

It is necessary to treat the malaria parasite from the point of view of malaria; that is to say, to consider its significant phases to be those which it passes in the human blood. In reality its mature condition and most important motile, as well as its most prolific reproductive, phases are passed in the body of the mosquito.

1. The malaria germ which is brought by the stab of the *Anopheles* into the human blood vessels is a reproductive particle, a spore. It is needle-like in shape, and might be named in reference to its form (for example, oxyspore or raphidiospore), but the most important fact about it for description and comparison is that it has been formed outside the human body, and is introduced as a strange element into the human blood by the agency of the mosquito. I therefore call it the exotospore.

2. The exotospores (probably as many at a time as forty or fifty) enter the blood by the agency of the mosquito's stab, and immediately penetrate, each one, a red corpuscle. The history of this process has not been observed. As soon as it has entered a red corpuscle the exotospore loses its needle-like shape and becomes amoebiform. I apply to it the name I proposed some years ago for similar amoebiform spores in other protozoa—namely, amoebula.¹

3. The amoebula exhibits amoeboid movements within the red corpuscle, enlarges and finally breaks up into spherical spores, which are liberated with destruction of the red corpuscle. It seems to me unnecessary to have a special name for the starlike or other condition of the amoebula when in course of breaking up into spores; but the spores so produced require a special name which shall emphatically distinguish them from the exotospores. I call them the enhaemospores, in reference to the fact that they are produced by a process of division which occurs in the blood of the malaria-stricken human being.

4. The enhaemospores penetrate fresh red blood corpuscles, and after a certain growth as amoebulae break up into a new crop of enhaemospores, by which the infection of the red corpuscles is extended. This process appears to go on for several generations, and for a varying duration of time. But owing to conditions and at a period of the infection which has not been precisely ascertained, some (or all?) of the amoebulae derived from enhaemospores cease to break up into spores. Instead of carrying out that process they enlarge, and in the case of the aestivo-autumnal parasite (*Laverania praecox*) become sausage-shaped or, as it has been termed, crescent-shaped. This change of form is accompanied by a destruction of the red corpuscle and the formation of granules of dark pigment within the parasite. It seems best to term this phase the "crescent" or "crescent-sphere," the latter term being applicable to those species in which the form is not markedly crescentic.

5. The crescents or crescent-spheres remain quiescent in the human blood. They are, however, of two different natures—male and female. It is not possible to distinguish with any certainty the male from the female crescents whilst they remain in the human blood vessels. But it is these bodies which are destined to be swallowed by the *Anopheles* mosquito, and to carry on further the life-history of the parasite.

The crescents are therefore the sexual phase of the parasite.

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When the crescents are swallowed by a mosquito (of an appropriate species), they undergo two different modes of development, determined by the fact of their sex. Both sexes become spherical, and may now be called respectively "egg-cell" and "sperm-mother-cell."

From the periphery of the sperm-mother-cell, now floating in the mosquito's stomach, there are developed with surprising rapidity six or seven spermatozoa, which for a time remain attached to the residual mass (or sperm-blastophor) of the sperm-mother-cell. Complete cytological study of this development is still wanting, but it appears that the spermatozoa are true spermatozoa, like those of the higher animals, and have the same relation to the mother-cell from which they develop as is the case in such an animal as the earthworm.

The egg-cell, now also floating in the mosquito's stomach, apparently gives rise to one, and possibly to two, polar bodies, but the observations on this point are as yet insufficient.

Fertilization of the egg-cell now takes place in the gnat's stomach. A single spermatozoon penetrates and fuses with each egg-cell.

The fertilized egg-cell is spoken of as a "zygote"; it is also described as the sexually-produced embryo.

6. The zygote or sexually-produced embryo remains unicellular, but increases in size and becomes pyriform. It exhibits active movements of expansion and contraction in the line of its long axis, and also a quick movement of its narrower end alternately to either side. This is the largest growth of the individual cell attained to in the series presented by the life-history of the malaria parasite. It has been called "vermiform" and "vermicule" (Ross), and I adopt this name for it, namely, the vermicule. The vermicule is the dominant individual form in the history of the malaria parasite, endowed with greater size, power, and activity than other phases. It corresponds, not only in this respect, but also in its position in the life cycle, to the large, often active, cells of the gregarinidea, which I proposed some time ago to call the euglena-phase.²

It is worthy of note that in the size and activity of the vermicule, the haemosporidia—the order of sporozoa which embraces the malaria parasite—come nearer to the gregarinidea than they do to the coccidiidea, though in the existence of a sexual generation absent in gregarinidea, they agree with the coccidiidea.³

The vermicule now pushes its way through the tissues of the gnat's stomach and in the blood sinuses outside the stomach becomes spherical. It enlarges and nourishes itself on the insect's blood, and forms a spherical cyst, or structureless transparent envelope. This cyst is destined to enlarge, with vast increase of its living contents.

The living cell within the cyst breaks up by a definite process to form eventually an immense number of exotospores, the stage with which the present description commenced. The cyst would most conveniently be called a "sporocyst," since, as so often happens in protozoa, it is formed purely and simply in relation to the quiescence of the organism and its division into numerous reproductive spores. Unfortunately, the word "sporocyst" has been employed recently by writers on the sporozoa for the small capsules containing one or two to eight elongated spores which used to be called "pseudonaviculae," and are formed within such larger cysts as that now in question. The word "cyst" should have been reserved for the larger more general protective envelope, and the "pseudonaviculae" might have been called "sporo-thekae." In any case, I think we may call the cysts in which the vermicules of the malaria parasite enclose themselves "spore-cysts" or "spore-forming cysts." The name "oocyst," applied to them by some writers, is simply misleading.

7. The spore-cysts lying outside the stomach wall of the mosquito bathed in the insect's blood receive abundant nourishment. The single-celled vermicule enclosed undergoes rapid changes; it increases greatly in volume, and breaks up by normal cell division (? the earliest steps have yet to be studied) into a number of spore-mother-cells. In the process of this division and the later stages of the final development of the "spores" (exotospores), the "spore-forming cyst" increases in size to twenty times its initial diameter.

The spore-mother-cells are set closely together in the cyst;