INSECTS AND WAR:

X.—THE MOSQUITO (*Anopheles maculipennis*).

BY

A. E. SHIPLEY, Sc.D., F.R.S.,

MASTER OF CHRIST'S COLLEGE, CAMBRIDGE.

Where the water is stopped in a stagnant pond,
Danced over by the midge.

R. BROWNING, "By the Fireside."

THERE is no zoological distinction between a mosquito, a gnat, or a midge. But, as a matter of convenience, we might confine the term "gnat" to the genus *Culex*, the term "mosquito" to the genus *Anopheles*, and the term "midge" to the genus *Ceratopogon* and its congeners, whose collocation with the naked knees of the Highlander is said to have given rise to the "Highland Fling."

There is no doubt about it that both the mosquito and the gnat are extraordinarily beautiful insects. This fact, however, has been veiled from the public partly owing to their small size and more especially because of their irritating bite, which causes the sufferer to kill a mosquito at sight rather than examine its fairylike beauty or its fascinating dances in the air, far surpassing in grace and agility anything seen in the Russian ballet. But biting is the dominating note of a mosquito, and we may as well consider, to begin with, how it bites.

If we examine the head of a mosquito we shall find that it is shaped like a circular cushion bearing two enormous eyes, so large that in the male they touch above the forehead and almost meet below the chin. Each eye consists of hundreds of facets of a brilliant green hue, set in a darkish background, like emeralds arranged on a black surface. The head also bears a number of hairs and flattened scales whose number, shape, and arrangement are of considerable systematic value.

The following are the appendages of the head:

1. A pair of antennae, which are markedly different in the two sexes.
2. A pair of mandibles. These are absent in the male.
3. A pair of first maxillae, each of which has a jointed tactile palp.
4. A pair of second maxillae which have fused together to form a deeply grooved soft process in which the other appendages lie.

Beside these four pairs of appendages, which are in reality modified limbs, there are two median processes, which project one from the top, the other from the bottom of the mouth, like elongated and hardened upper and lower lips. These are the median labrum above, a deeply grooved structure whose edges approximate and almost touch, thus forming a tube along which the blood of the

Fig. 1.—Side view of the head of a female *Anopheles maculipennis*, magnification about 20, with the various mouth parts separated, but in the relative position in which they lie when enclosed in the groove of the labium. This figure shows the characteristic cephalic scales. a, Antennae; c.s., cephalic scales; cl., clypeus; lxe, labrum + epipharynx; mn, mandible; hp, hypopharynx; mx, first maxilla; li, labium; mp, maxillary palps.

victim is sucked. Lastly, there is the hypopharynx, sometimes termed the tongue, a median structure, a double-edged sword, rising from the bottom of the mouth, and it is this that is the cause of all the trouble.

A glance at Fig. 1 will show how these various mouth

appendages can by a skilful use of dissecting needles be separated out, but in nature they are all packed together in a case; the arrangement in the case is shown by Fig. 2, which represents a transverse section of the proboscis.

The term "proboscis" is given to the totality of all these structures taken and packed together. With the exception of the labium and of the tactile maxillary palps all the mouth appendages lance into the skin. The proboscis of the male is, however, too weak to pierce the human integument, and it is the female which does all the damage. When a mosquito is going to bite, she alights so gently that her approach is unperceived, and she proceeds to thrust her arsenal of weapons into the epidermis of her victim almost unfelt; the feeling comes later. These weapons are all guided, by the forked end of the softened labium, just as one's finger-tips guide the end of a billiard cue. These "mouth parts" are exceedingly fine, extremely sharp-edged structures, whose consistency is about that of whalebone, and both the mandibles and the maxillae have a toothed, serrated edge (Fig. 3). They are partly pushed in

Fig. 2.—Transverse section through the middle of the proboscis of a female *Anopheles maculipennis*, showing the relative position of the parts when at rest. Two tracheae and two pairs of extensor and flexor muscles are seen in the labium. lxe, Labrum + epipharynx; tr, trachea; mus, muscles; hp, hypopharynx; sal, salivary duct; mx, first maxilla; mn, mandible.

by muscles in the head, partly, I think, by the lowering of the body, and they sink slowly and surely into the flesh with as much ease as a paper-knife will penetrate a cream cheese. But as they sink deeper and deeper into the integument the body of the mosquito approaches nearer and nearer to the skin of the victim, and the labium is pressed further and further backwards until at the end of a satisfactory puncture the distal and proximal parts of the labium are parallel and touching.

It is rather an interesting point that the labium does not enter the skin, because the larvae of certain *Filarias*, one of which produces elephantiasis in man, and the other severe heart trouble in the dog,

are found in pairs, probably a male and a female, in these labia of mosquitos. How exactly these nematode larvae leave the labium of the mosquito, and enter the body of the man and the dog, has not definitely, I believe, been cleared up, but that they do enter the human and the canine skin seems certain.

We have mentioned that the labium is a grooved tube with its edges practically in proximity, and it is up this tube that the blood of the bitten is sucked by the well-known suctorial pharynx which occupies so large a part of the interior of the head of a mosquito. Much the most dangerous weapon of the whole armoury, however, is the hypopharynx. This is shaped like a double-edged sword with a very minute groove running down the centre; this

Fig. 3.—A side view of the labellae and piercing organs of the proboscis of a female *Anopheles maculipennis*, dissected out to show the tips of the mandibles, maxillae and labrum + epipharynx. The hypopharynx is not shown. li, Labium; lxe, labrum + epipharynx; mx, first maxilla; mn, mandible; la, labellae.

groove is so minute that Professor Nuttall and I and others for some time took it to be a tube. It receives at its base the products of the salivary glands of the mosquito, and it is these products which contain the organisms which cause malaria—a disease which has probably caused more trouble and has played a greater part in the history of the world than any other malady to which humanity is heir. Down this minute, microscopic groove has flowed the fluid which has closed the continent of Africa for countless centuries to civilization, and which has played a dominating part in destroying the civilizations of ancient Greece and of Rome.

When the adult mosquitos (the imago) leave their pupa cases they are unable to pierce the human skin until the mouth parts have hardened, which takes at least six hours. In England they can undoubtedly feed twenty-four hours after leaving the pupa case. When feeding, both the sensory antennae and the tactile maxillary palps are thrust forward at right angles to the proboscis. They thus test the place where the two-lobed extremity of the labium will guide the battery of stylets into the substance they are feeding on. The female is much more voracious than the male, which, as we have mentioned above, cannot pierce the human integument, and has to be content with a vegetarian diet. Sometimes the effort even of the female mosquito to insert its proboscis is fruitless, and we have watched a mosquito attempt four times to pierce the skin before it drew blood. If undisturbed during the meal the suctorial repast may last some two or three and a half minutes. So greedily at times is the mosquito that she resembles Baron Munchausen's horse after the adventure with the portcullis. What was flowing in at one end was flowing out at the other. After the process of biting, of sinking in of the piercing needles, is complete, the proboscis is withdrawn, and to do this the mosquito braces herself on her legs and raises her body.

Another curious feature about the head of *Anopheles* is that it is pierced by two chitinous, symmetrical tunnels—tubes which are open at each end with trumpet-shaped orifices. The use of these is probably to act as a stay or strut to strengthen the chitinous exoskeleton of the head; but these queer galleries or tubes also to some extent act as an attachment for muscles.

The antennae vary very much in the two sexes. In the female there are fifteen segments, each bearing a ring of hairs, but of small and disproportionate size, whereas in the male the bushy character of the hairs is conspicuous even to the naked eye. In fact, it is the best criterion for judging the sex of the insect. At the base of the first joint of the male antenna is a deep cup-shaped structure packed with sense organs, and containing a large nerve ganglion. There are sixteen segments in the whole antenna, one more than in the female. The hairs are capable of movement, and as a rule are kept closed on the shaft of the antenna whilst not in use; when evening comes on they are spread out. There seems little doubt that these organs are olfactory and help the male in searching for the female.

The beautiful transparent wings of the mosquito are beset with minute spikes which serve to break up the light and to give rise to the many coloured iridescence of the creature's wings. The posterior border of the wing bears rows of beautifully graded scales. These add much to the symmetry and beauty of the whole structure. Just behind it are two balancers, or halteres, a name derived from the Greek word *ἀλτήρες* meaning a kind of dumb-bells which athletes used in the stadium when jumping. These so-called balancers project outwards and backwards from the body when the wings are in a position of flight.

A curious distinction between the *Culex* and *Anopheles* is in regard to the position assumed by the male when it rests. In *Anopheles* the proboscis and body are almost in one line, and the axis of the body is at an angle with the surface upon which it rests. *Culex*, on the other hand, has its proboscis at a slight angle with its body, and its body is almost parallel with the surface upon which it is perching. *Culex* has a much more hump-backed appearance than *Anopheles*, and its legs are considerably shorter and stouter. The insect generally rests upon four out of six legs; in the former case the hinder pair are held out and curved upwards. The hind legs not infrequently serve as a test for food. When feeding upon sweetened milk or fruit, the moment the hind leg touches the fluid or

juice the insect will wheel round and at once begin to feed.

Anopheles maculipennis is very widely distributed, and it has been recorded from most parts of North America and Europe and from many parts of Asia. Probably it is much more widely distributed than we have any record. Individuals do not wander very far, of their own accord, from the breeding places, but they may be blown by the wind. Cases are known where they have been blown as far as ten or even twenty miles, and in camping in Africa, it is always well to keep to the windward of a native village. They are also carried about by trains, motors, and steamers. They do not indulge in any such voluntary migratory flights as the locusts; although some such flights have been from time to time recorded, they are probably due to a high wind catching a large number of mosquitos temporarily together.

In a joint paper which Professor Nuttall and I wrote some years ago, we drew attention to a case in which mosquitos came aboard a ship some ten miles from land, and in another in which a Spanish barque from Rio de Janeiro was quarantined in the South Atlantic quarantine station of the United States. The vessel was so much infested with mosquitos that it was rendered nearly uninhabitable, and the United States quarantine officer reported that when the fore-castle was opened after fumigation "the mosquitos could be scooped up by hand." The master of the barque was positive that there had been no mosquitos on board until the twenty-second day out. Howard quotes a letter from a general living in Texas in which he states he has "twice seen flights of *Culicidae*," but as the species and the genus are not given, much of the interest of the statement evaporates.

RECENT ADVANCES IN THE RELATION BETWEEN CHEMICAL STRUCTURE AND PHARMACOLOGICAL ACTION.*

BY

J. M. FORTESCUE-BRICKDALE, M.A., D.M.Oxon.,
M.R.C.P.,

SENIOR ASSISTANT PHYSICIAN, BRISTOL ROYAL INFIRMARY.

PHARMACOLOGY occupies a tract in the domain of science between the kingdoms of the chemist and the physiologist; it is, as it were, a "buffer state," and can be approached from either region. But, as far as I know, no boundary commission has ever attempted to completely delimit its borders. Both avenues of approach to the subject offer certain advantages and disadvantages. Chemical knowledge is perhaps more precise and definite, but, on the other hand, the large number of varied and complex substances dealt with, and the comparatively few far-reaching generalizations which can apply to pharmacology, render the material to be presented difficult to arrange in a concise way.

Our ignorance of the physico-chemical reactions of the bioplasm and the mechanisms by which it responds to chemical substances introduced into the organism makes a purely physiological outlook on this subject almost impossible; so that for our present purpose I think a combined scheme of approach will best suit the circumstances. I propose, therefore, to consider the relation between chemical structure and pharmacological action on a primarily physiological basis, the secondary classification being chemical. I propose to trace the points in its passage through the organism at which alterations in its structure may modify the physiological action of a chemical substance, classifying these alterations on chemical lines, so that in all cases chemically comparable bodies will be grouped together.

I.

Before absorption structure may modify action indirectly by its effect on physical properties. Increasing the size of the molecule and extending the chain (as in the paraffin series) alters gaseous or liquid bodies, which are easily absorbed, into insoluble solids (the higher paraffins), which are devoid of action because they are not absorbed. Modifications which render substances more or less

* An introduction to a discussion of the subject in the Section of Pharmacology, Therapeutics, and Dietetics, at the annual meeting of the British Medical Association at Aberdeen.