larva, if these should happen to differ materially. It is often of advantage that there should be division of labor between the several stages of the life history, and the functions of migration and growth may be allotted to special times of life instead of being carried on throughout. Migration is naturally associated with lightness and activity; feeding and rapid growth are favored by a sedentary habit. If such division of labor should take place, as it commonly does in crustaceans and insects, the crustacean will find it convenient to perform its migration early, when it has little armor to carry, and when its surface is large in proportion to its weight. The Zoæa will do little more by its own exertions than maintain the right attitude and the right distance from the surface of the sea, leaving the currents to effect the actual transport from place to place. Migration over, it will settle to the bottom, acquire heavy armor as a defense from its many enemies and begin to feed in earnest, becoming in the end a slow and heavy inhabitant of the sea bottom. With the insect the procedure will be reversed. Being unable to travel far while small and weak, it will feed first, and having attained its full size, will then, if at all, acquire special means of locomotion. Wings are more efficient as a means of transport than any other organs of locomotion of which a terrestrial animal can avail itself; but flight is so difficult an exercise that wings, if acquired at all, will be acquired late.

Marine animals commonly produce far more eggs than insects.* The risks of the shallow seas are so great that a small proportion only of the young animals comes to maturity. Hence the enormous fertility of common marine animals, except such as are able to nourish or defend their young. Where a vast multitude of eggs hatch out together, dispersal in search of food becomes an immediate necessity.

The more sluggish and sedentary the adult, the greater the activity we may expect to find in the larvæ. It is they which have to travel and to find out suitable quarters. But they often make up by their numbers for any deficiency in enterprise or intelligence. Vast numbers of Zoæas are swept into midocean or into tidal rivers or are devoured. It is only a chance remnant that survives.

Just as the sluggishness of the adult crustacean or echinoderm may promote activity in the young, so the activity of the adult insect may discourage activity in the young. The power of flight possessed by most adult insects favors a sedentary life in the larva, which is spared all effort in connection with the dispersal of the species, and can give its undivided attention to feeding. Accordingly the larva often degenerates more or less, especially when its food is abundant and obtained without labor or risk. The sagacity and industry of the bee in storing its cells with honey may be said to have cost the larva its legs. So, too, the active and highly gifted blowfly, ichneumon, and gall fly secure abundant food for the new generations, which emerge as footless grubs. In the Coleoptera we find that the larvæ, which feed on dead vegetable matter beneath the surface of the ground, are heavy bodied and short legged, sometimes so overloaded by the weight of the abdomen that they rest lying on one side. The larvæ of weevils, which are vegetable feeders and often buried in the plant which they devour, are commonly without legs altogether. Even the head of the larva may be reduced almost to nothing by the labors of the adult insect. The blowfly finds out a practically inexhaustible supply of carrion in which to lay its eggs, and the larval head is so reduced that it consists mainly of a pair of large hooks, with muscles to work them, and a chitinous frame to form a fulcrum for the muscles.

The degeneration of the larva can only proceed far when the adult undertakes the dispersal of the species. That is why, it seems to me, the larvæ of marine animals, though often very unlike their parents, are not really to be called degenerate. They cannot be supposed to have arisen from ordinary forms, typical of the class, by mere disuse and reduction of the organs of active life. On the contrary, they are often immature forms specialized for locomotion.

Even when the adult undertakes the dispersal of the species, the larva does not necessarily become degenerate. The winged locust is the chief agent in dispersal, but the larvæ are active, seek their own food, and exhibit no marks of degeneration. It is only when their choice and responsibility are taken away, when they are encouraged to feed almost without intermission, or to bury themselves out of sight, that they degenerate.

Parental care and all labors undertaken by the parent for the sake of the offspring tend to promote helplessness in the young. The helplessness of the higher vertebrates at birth, as well as their prolonged fetal development, are due to the fact that their parents are able to find them food and protection. Here there is no degeneration in the young; though helpless, they are of the same zoological grade as their parents. The locomotive organs and the senses of a baby or a nestling bird are as complex as those of the adult, and are merely feeble for want of skill and exercise. In the larval insect there may be real degeneration, fewer limbs, fewer joints in the limbs, deficiency of sense organs, relative preponderance of the organs of nutrition. If the transformation of insects had never been traced, the structure of the two stages would have inevitably led zoologists to place the caterpillar in a lower class or order than the butterfly.

There has been much speculation as to the form of primitive insects. Fritz Müller supposes that the wingless Orthoptera come near to the original stock, while others have derived all insects from the wingless and non-metamorphic Thysanura. By taking what is common to the least modified Orthoptera and the Thysanura, and rejecting all features peculiar to either, we shall certainly get a highly generalized insect, such as might possibly be a common ancestor for the whole group. Brauer pointed out that such primitive insects still survive in Campodea and Japyx, which have mouth parts (as Lubbock considers) "intermediate between the mandibulate and haustellate types," one

pair of many jointed antennæ, three pairs of long legs, and an abdomen whose first seven segments bear pairs of rudimentary appendages, while the tenth and last segment bears in Campodea a pair of many jointed appendages, in Japyx a forceps. Campodea and Japyx have no eyes, but this is not considered typical; simple eyes are usual in insects of the same grade. They undergo no metamorphosis.

Brauer finds forms closely resembling Campodea among the larvæ of Orthoptera, Perlidæ, Odonata, Ephemeriidæ, Coleoptera and Neuroptera. In Strepsiptera and Coccidæ he considers that they are present in a more modified form. No Campodeiform larvæ occur among Lepidoptera, Hymenoptera, or Diptera.

Brauer looks upon the caterpillar of Lepidoptera, sawflies and Panorpa as a degenerate Campodea, while he considers the apodous maggot of many Coleoptera, some Neuroptera, bees and Muscidæ as a still more degenerate larva, derived from, and not historically antecedent to, the Campodea. Grassi and others have brought forward facts to show that the maggot-like bee larva has previously passed through a kind of Campodea stage.

Lubbock regards the caterpillar too as essentially a Campodea. But this extension seems to me to take all definiteness out of the Campodea form. If every larva with biting mouth parts and six legs is to be called a Campodea, we still want a name for the larva which has long legs, long antennæ and at least one pair of abdominal appendages.

Brauer's Campodea seems to invite comparison with Scolopendrella and Peripatus; just as the more generalized Campodea of Lubbock invites comparison with the hexapod larva of Diplopoda and Atax. I do not venture to pursue these comparisons, which involve difficulties not apparent at first sight, and will only remark that the former comparison seems to throw most light upon the phylogeny. The leg-bearing segments of the Diplopoda are apparently not the same as those of insects, and the embryology of insects points to a polypod, rather than to a hexapod, as the common ancestor of the Tracheates.

If it seems rash, with our present knowledge, to trace the phylogeny of Peripatus, the Myriopods and the insects, what shall we say of Lubbock's far bolder attempt to derive his Campodeiform larva from a Rotifer-like ancestor? It is suggested, though not positively asserted, that certain apodous dipterous larvæ exemplify this earlier stage. I must declare myself altogether skeptical as to a Lîndia stage antecedent to the Campodea. The only apodous insect larvæ known to me are born of highly specialized insects, and have apparently become degenerate in consequence of the completeness of the provision made for them by the intelligence or special instincts of the parent. They are, as Brauer humorously says, like the sluggish in Hans Sachs' Lubberland, who required roast pigeons to fly into their mouths. I see in them no mark of a primitive insect.

Brauer in 1869 was ready to derive the maggot from the caterpillar, and the caterpillar from the Campodea (p. 310). He points out, very truly, that the reduction of the larval head of the Diptera may be gradually traced from forms in which it is perfectly developed. It is a pity that he did not bear his own explanation in mind when at a later date he attempted to arrange the Diptera Nemocera by characters largely drawn from the degree of development of the larval head. The unsatisfactory nature of the result has been pointed out by Baron Osten Sacken (Berl. Ent. Zeits., Bd. xxxvii, p. 417, 1892).

That Brauer's arrangement of the Nemocera does not, in the opinion of experts, associate allied forms, shows that he has been unfortunate in his use of larval characters. Could that result have been anticipated? Is there any general objection to the employment of larval characters in the definition of large groups of insects? I think that there is. In his paper of 1869 Brauer, following Fritz Müller, remarks that the development of various insects has been either abbreviated or falsified. He thinks that the Hemiptera have lost a transformation which they once possessed. He thinks that Dipterous larvæ and others have been acted upon by conditions of life which have not affected the imago. Yet he has employed characters which he knew to be highly adaptive and also finely graduated, for the definition of his tribes and families. Brauer is both a systematist and a philosopher, but his system forgets his philosophy.

(To be continued.)

THE STRUCTURE AND FUNCTION OF THE HORSE'S FOOT.*

By Veterinary Captain F. SMITH, F.R.C.V.S., F.I.C.

THE structure and function of the horse's foot is a subject which is not only of theoretical interest, but of supreme practical importance. When I tell you that half the unsoundness and at least half the lameness among horses in this kingdom are due to trouble either in or near the foot, you will, I am sure, agree with me that it is impossible to overestimate the importance of the subject which I have to bring before you this evening.

The reason why the foot should be such a frequent seat of unsoundness is not difficult to understand when we remember the unnatural conditions under which horses both in town and country have to work, and, further, the risk they incur from shoeing.

Shoeing is a necessary evil, but the harm resulting from the application of a shoe to the foot is not in itself great; it is the abuse of shoeing which constitutes the danger. The serious and senseless mutilations which are practiced on the foot rob shoeing of much of its value, and constitute it a standing reproach to our civilization.

I regret that the time at my disposal will not admit of the question of shoeing being touched on; but during this discourse, as opportunity occurs, I will allude to some of the great evils which are practiced in this indispensable art, evils which I may at once say might in a few months be swept away throughout the length and breadth of the land, if the horse-owning community possessed even an elementary knowledge of the manner in which the horse's foot is built up, and the use of its various parts.

It is probable that the majority of laymen regard the foot as a solid block of horn placed at the end of the limb, and on which the horse stands. I shall hope to show you that the foot is a highly specialized structure, endowed with tissues possessing acute sensation, mechanisms by which concussion is warded off, a blood supply unequaled in any other part of the body, the whole being inclosed within a covering of horn known as the hoof.

The foot is therefore divided into two parts, a core consisting of bones, blood vessels, tendons and other tissues, which in shape resembles a miniature hoof, and enveloping this a covering of horn possessing neither blood vessels nor nerves; the first is called the sensitive, the other the insensitive foot, and the two fit together much as a finger fits into a glove.*

Various names have been given to the different parts of the foot: For instance, the wall is the portion visible when the foot is on the ground; the position of the sole is obvious; while a wedge-shaped piece of horn placed in the central and posterior part of the foot is vulgarly known as the "frog"—we shall speak of it as the foot pad; finally, a portion of the wall inflected at the heels forms a part known as the bars.

It is impossible to completely grasp the function and structure of the foot unless we possess some information as to the nature of horn.

If horn be examined under the microscope, it is found to consist of cells which resemble the scales found on the skin; in fact, hoof is modified skin, the cells forming which have, by a process of compression and chemical change, become converted from scales of skin to scales of horn.

The essential microscopical feature is the presence of canals, around and between which the cells are arranged, uniting and knitting the parts together in such a way as to produce the tough, yielding material known as horn. The tubes run through the entire length of the structure. They are not completely hollow, as the name might imply, but are lightly packed with very soft cells.

Horn which is dry, as in any of the feet on this table, is as brittle as glass and fractures like a piece of glue. Horn which is moist cannot be broken; it can be twisted and torn, but only with difficulty. Under pressure the moist horn yields, the dry horn breaks.

The moisture in the foot is something very remarkable. In the foot pad it amounts to 42 per cent., while in the wall, which is the driest, it falls to 24 per cent. The use of this moisture is to keep the foot pliable and yielding; where, therefore, the greatest yielding is required there the moisture is the largest, and where resistance is most needed there the moisture is the least. I shall constantly have to refer to the moisture in horn, for, as you will see later, it is the essential factor in the foot around which all the others work.

It is through the cells and tubes in the horn that a constant passage of water occurs, by which means the foot maintains, in spite of the evaporation which is taking place from it, the amount of moisture it requires.

We spoke of the sensitive being buried within the insensitive foot; it is from this sensitive foot that the horn is secreted, the process being a slow and gradual one.—If we examine a horn-secreting surface, it will be found covered with delicate projections known as papillæ, about one-quarter to one-half inch in length; these papillæ fit into holes in the horn, and the tubular formation of horn is due to the fact that it is pierced at its origin for the reception of papillæ.

The wall of the horse's foot is divided, for convenience of description, into the toe, quarters and heels. The thickness is greatest at the toe, and decreases gradually toward the heels, where it is thinnest; but the wall at the heels, instead of being continued so as to complete the circle of the foot, suddenly turns in and travels in a forward direction between the sole and foot pad. This portion is called the bar, and the practical lesson which has to be learned is that the bar is part of the wall, is intended to bear weight and should not be cut away in shoeing, as is so commonly practiced. In a foot of a wild horse shot in Tibet—of which a plaster cast is placed on this table—the most extraordinary development of the bars is shown.

It is obvious that by the inflection of the wall the heels of the foot are considerably strengthened; and this is especially necessary, as the circle of the wall is only an imperfect one.

The amount of moisture in the wall varies, depending upon its position relative to the horn-secreting surface. The horn-secreting surface of the wall lies immediately under the upper edge of the hoof; the nearer the horn is taken to this upper edge, the more moisture it contains, the further from the edge, the less the moisture. It is obvious, therefore, that as the wall grows longer it becomes drier, and moderate dryness of horn is only another name for toughness, so that the portion of wall in contact with the ground is much harder than the portion above the ground.

The growth of the wall under normal conditions is the same at any part of its surface; if it grows an inch at the toe, it grows an inch at the quarters and heels. You will observe that the wall at the heels is, roughly, only half the height of the wall at the toe, and, bearing in mind what has been previously said about horn becoming drier as it increases in length, you will have no difficulty in understanding that the horn at the toe is older and tougher than the horn at the heel, which, from being much younger and shorter, contains more moisture and is, therefore, elastic and yielding. If, for example, we assume the length of the wall at the toe to be four inches, and that at the heel to be two, it is obvious that the wall at the toe is double the age of that at the heel; and if we continue this investigation further by drawing lines around the wall parallel with the upper edge of the hoof, it will readily be seen that the portion in contact with the ground is of varying age, being oldest at the toe and gradually decreasing in age to the heel, in other words, being hardest at the toe and softest at the heel.

There is an object in all this which we must now inquire into. When a horse's foot comes to the ground in either the trot, canter or gallop, viz., in any pace which causes concussion, the heel is the first to make contact with the ground; by this means, as we shall

* No statistics have been collected to my knowledge on an extensive scale. Very many insects lay their eggs singly. In particular cases (social insects, Meloidæ, etc.), where special reasons obtain, they may be laid in great numbers, but my general impression is that the eggs of Echinoderms or marine Crustaceans would be far more numerous as a rule.

* A paper read before the Royal Institution of Great Britain, May 3, 1895.

* A working model of the foot twelve times its natural size was kindly built for this lecture by Captain Gillespie, army service corps, to whom I am very greatly indebted.

hope to show, the shock of impact is considerably reduced, for the soft tissues of the posterior part of the foot yield slightly under the strain instead of offering rigid opposition, and this yielding, which we shall have to deal with more fully later on, is permitted to occur through the young moist horn which exists at this part.

From the heel the weight is transmitted along the foot from rear to front, and finally the heel becomes raised, the toe alone bearing on the ground. This is the position in which the greatest wear and tear of the foot occurs, for the toe is now engaged in giving the propulsion to the body, the friction is, therefore, considerable, and to meet this the horn at this part is comparatively dry and very tough.

We can see, therefore, that the variations in the amount of moisture in the wall are intended to meet the wear and tear of the foot.

The use of the wall is to support the weight of the body; the horse's weight is literally slung inside its foot. This slinging apparatus is infinitely stronger than if the weight were imposed, as we might imagine, on the sole of the foot, and, in addition, it is distributed over a larger surface than it otherwise would be.

When we remember that the mean weight of a horse is 10 cwt., and there are many which weigh 15 cwt. or more, there is no difficulty in observing that the foot is really an extremely small base on which to impose this enormous weight. The area of the human foot appears to be greater than that afforded by the horse's foot, but I shall now have to show you that the slinging apparatus previously spoken of increases in a remarkable manner the internal surface of the horse's foot without adding to its circumference.

Found on the inside of the wall are 500 or 600 plates or leaves of horn which run in the direction of the fibers of the foot—they may be seen in this model. In length they nearly correspond to the wall, while they are so thin as to be perfectly transparent. Regarded by themselves, their function is not very evident; but if we examine the exterior of the sensitive foot, it will be observed that it is covered with a very large number of delicate sensitive leaves, also of extreme thinness, and so full of blood vessels as to give a bright red color to the part.

These sensitive leaves or laminae correspond in number and position to their insensitive counterpart, and the two sets are found to be fitted into each other in such a way as to form the most perfect dovetail.

This dovetailing of the laminae produces immense strength; by no ordinary process is it possible to destroy the union of these two surfaces, even after death; special methods have to be adopted in the study of anatomy if we wish to separate the horny from the sensitive laminae.

But the dovetailing is further increased in strength by a remarkable arrangement. If we make a horizontal section of the two sets of laminae in position and examine them microscopically,* we find that each lamina, both horny and sensitive, possesses secondary laminae or lamellae; of these there are about 150 to each primary lamina, so that we may say the union between the sensitive and insensitive walls is brought about by the dovetailing of 1,000 primary and 150,000 secondary laminae.

Here is a model of a single lamina 450 times larger than normal. The structure rather reminds one of a fern leaf or feather, the stem being the primary lamina and the lateral projections the secondary leaves.

So much for the slinging apparatus. If time permitted I could tell you much more of interest about it; and the undoubted evidence we possess that by it, and it alone, is the enormous weight of a horse's body solely supported.

We have one more point to discuss in connection with the laminae, and that is the increase in the surface which they afford to the foot. The simplest method of explaining my meaning is to take the commonplace example of a book consisting say of 500 pages, which when bound in the ordinary manner is easily compressed into a body having a small surface, yet if each of the 500 pages be removed and placed side by side, the area they cover would be considerable. Much the same arrangement exists in the foot. By the folding up of horny and sensitive material a very large surface is disposed within a very small circumference, and careful measurements of the primary and secondary laminae have led to the conclusion that the surface thus contained within each foot of the horse is not less than eight to ten square feet.

The next part of the foot to receive attention is the sole. This, as may be seen from the model and diagrams, is concave in shape toward the ground, which is evidence, if any were required, that it is not intended to support the horse's weight; that margin of it, however, in contact with the wall is doubtless capable of sustaining pressure.

The function of the sole is to save the sensitive parts situated above it from injury, and that it is eminently qualified for this purpose is evident to any one who has witnessed the intense lameness which arises from a stone getting wedged in the foot.

The sole grows from the sensitive sole, which may be seen in the diagram to be scarlet in color and covered with numerous projections, or papillae, which fit into minute holes on the upper surface of the horny sole.

A peculiarity in the horn of the sole is the fact that it only grows a certain thickness before it breaks off. The object of this is, that as the sole over its general surface is not in contact with the ground, it is exposed to little or no friction like that of the wall, which in a state of nature is maintained of proper length by the friction to which it is exposed. The sole is therefore shed on attaining a certain thickness, but no shedding occurs until a new sole of suitable thickness has been produced to take its place.

One of the common evils of shoeing is cutting away the sole of the foot. If we bear in mind the use of the sole, I am sure the ruin produced by this barbarous practice will be very evident to you. The sole cannot be too thick, and I have shown you that nature provides for its exfoliation. Under the weight of the horse's body the sole slightly yields; but this we will discuss presently.

The foot pad, or, as it is commonly known, the frog, is peculiar both from its shape and the nature of its horn. The horn forming this body is very soft, and resembles rubber; it can be cut, but offers considerable resistance to friction, and when exposed to friction it wears away with a ragged surface in much the same way as rubber. Its pliability is due to the considerable amount of moisture it contains, which you may remember I stated was as high as 42 per cent., or about double that found in the wall.

This foot pad has a sensitive counterpart, a body composed of fibrous material containing fat, and so like fat in color that it has been termed the fatty frog. This sensitive foot pad fills up the entire space between the heels of the foot, and forms a dense cushion exactly resembling in shape the foot pad, and it is from the surface of this cushion that the horny foot pad grows.

There is no part of the horse's foot which has been exposed to more mutilation in shoeing than the foot pad; probably there is no part of the equine less understood, or one where more ignorance has been shown.

The impression among laymen is that the foot pad is a dangerous excrescence, which regularly at every monthly shoeing must be cut away to prevent the horse from becoming lame. This practice, I regret to say, is countenanced by people of intelligence, who in the matter of horse shoeing place themselves entirely in the hands of their servants.

The use of the pad is to save the foot and limb from concussion: its position in that part where I previously told you the largest amount of concussion is inflicted is evidence of this; further, the rubberlike nature of its horn is suggestive of a mechanism for the prevention of jar and shock. The shape of the pad, and the fact that in the unshod or carefully shod foot it is in contact with the ground over a large surface, is evidence that it must assist in providing a firm foothold and prevent slipping. Finally, from its position and use it keeps the heels apart and maintains the proper width of the foot.

All these facts can be absolutely demonstrated. Take, for instance, the last function accorded the pad, viz., maintaining the proper width of the heels of the foot. A simple experiment will demonstrate this to perfection. If we take a foot with a large well developed pad, and so shoe the horse that it does not come in contact with the ground, the heels of the foot become narrower every day, and in three months' time the part is beyond recognition, the heels have curled in, the pad has folded in on itself so that it is not one half its original width, and the fibrous cushion previously mentioned as lying above the foot pad wastes away as it is thrown out of use.

We may now reverse the experiment, and shoe the horse in such a manner that what is left of the foot pad is made to rest on the ground: in a month, or even less, the most marked changes have occurred, the pad commences to unfold itself like a bud, the cushion becomes larger, the foot wider, and in three months the transformation may be complete. Such is an experiment which may be performed on any horse with absolutely identical results, and proves to demonstration that the pad is intended by nature to rest on the ground.

We must now take a cursory glance at the internal foot, as our time will not admit of a complete examination.

The bones found in the foot are three in number: two wholly belong to the foot, one belongs partly to the foot and partly to the portion of the limb above the hoof known as the coronet. Dealing only with the foot bones, one is found to resemble a miniature hoof in shape, is very porous in its structure, and has growing from each extremity a plate of cartilage which extends superiorly above the hoof and posteriorly as far back as the heels. The bone is porous to admit of the innumerable blood vessels for which the sensitive foot is remarkable, while the introduction of the plates of cartilage is to allow of lateral movement in the posterior part of the foot, such as would not be possible if bone existed in its place.

The second bone of the foot is one of the smallest, but practically one of the most interesting in the body. Its position can be seen in this model; and it is unfortunately the seat of the most incurable lameness to which the horse is liable. Beneath this small bone is a tendon which flexes the foot and keeps the bone in position.

Surrounding all these are the sensitive structures to which previous reference has been made. But before passing on to the final subject for our consideration, I must draw your attention to the remarkable vascularity of the foot; in few parts of the body do we find so many blood vessels. These diagrams can give you but a faint notion of the number of vessels in the foot, and even they deal only with the veins; to have introduced the arteries would have complicated the drawing too much. Practically the whole of the sensitive foot is scarlet in color, from the amount of blood it contains, and the sole use of this blood is to manufacture the horny covering.

We alluded just now to two plates of cartilage found in the foot; they occupy the position shown in the diagram, and their use is connected with the important lateral movement or expansion which the foot undergoes when weight is placed on it. If it were not for these elastic plates, expansion of the foot would be rendered very difficult. The plates also assist the circulation of the blood in the foot, by exercising, during their elastic movements, pressure on the veins, and thus pumping the blood out of the part.

Perhaps the greatest interest in the foot is centered in the mechanisms which prevent concussion, these are as follows: lateral expansion of the foot, descent of the vascular within the horny foot, flattening of the sole, and sinking of the heels.

The expansion of the foot has been known for many years, but has always found more opponents than supporters; it was not until the introduction of foot apparatus which was capable of making delicate measurements that it was possible to convince the incredulous. Lungwitz, in Germany, has made some valuable observations on the expansion of the foot. Independently and unknown to each other we were both reinvestigating the phenomenon with improved apparatus, and obtained results which were practically identical. I show you on the screen the apparatus

employed by Lungwitz, which consists chiefly of a shoe to which can be fitted an arm carrying a screw. To this arm one pole of the battery of an electric bell is attached; the wall of the foot is covered with tinfoil carefully secured in its place, and to it is attached the other pole of the battery; the contact screw is so adjusted that if the foot widens when the weight is placed on it, the tinfoil touches the screw and so closes the circuit, of which the bell gives the indication. With this and other apparatus Lungwitz investigated the movements of the foot not only at rest, but during work.

I have been unable to investigate the movements of the foot during work, but on the table may be seen a piece of apparatus constructed on the same lines as that employed by Lungwitz, and with it I shall be able to show you, even on the dead foot, that there is marked lateral expansion. There is another piece of apparatus which I have employed, not only to indicate lateral movement in the foot, but to register the amount. The apparatus is constructed on the lines of a well known form of steam gage; a pin is connected with a series of wheels which multiply its movement, and convey this for the purpose of registration to a hand working on a dial; a very small amount of movement in the pin gives rise to a considerable excursion of the hand on the dial; by dividing the dial into a certain number of parts and carefully estimating their value by means of a vernier, an apparatus capable of registering the $\frac{1}{100}$ of an inch is readily obtained. I have this instrument on the table; it is placed against the wall of the foot at any desired spot, and, by lifting up the opposite leg, and so throwing extra weight on its fellow, the foot expands. A large number of observations carried out on these lines demonstrated that during rest simply imposing extra weight on one fore foot by lifting up its fellow caused it to expand $\frac{1}{10}$ of an inch.

It may be asked what is the value of this trifling increase? My answer is that this "give" makes all the difference between a rigid and a yielding mass, the slight yielding saves the foot from jar and concussion. It is obvious that the amount of "give" depends upon the force with which the foot comes to the ground, viz., on the pace, but under no circumstance is it likely to be more than $\frac{1}{10}$ of an inch.

The only part of the foot which expands is that portion of the wall situated toward the heels.

On this large model I have shown you in section the arrangement of the bones within the foot, and I pointed out the existence of a small but exceedingly important bone, the seat of an incurable lameness. The question arises as to the use of the navicular bone. My reply to a rather complex question must be brief—it is to increase the area of the pedal joint. It is obvious that an increase in the area of the joint could have been obtained by making the pedal bone itself larger, instead of introducing a third bone into the joint for the purpose. You will, however, observe from this model that the navicular bone has a movement quite independent of that of the pedis. It gives slightly when I press upon it and then returns to its place. Bearing in mind what I told you early in this lecture, that the heel of the foot comes to the ground first in all fast paces, you will be able to see that this small and troublesome bone really forms a yielding articulation, on to which the first force of impact is imparted, and in this way concussion is prevented. When this bone becomes diseased the animal, as we might imagine, goes on its toes and loses all freedom in its gait.

The next mechanism to be described is the descent of the vascular within the horny foot, a process which can be perfectly seen in this model. The whole of the vascular foot under the influence of the body weight sinks or becomes depressed within the hoof, to rise again to its position when the weight is taken off the limb; to revert to our original simile, the finger slides up and down within the glove. The amount of this movement is about one-sixteenth of an inch. The effect of it is that the foot offers an elastic and not a rigid resistance to the concussion of impact, and in this way neutralizes the jar which would otherwise be felt. In the same way that it is easier to catch a cricket ball by a retreating movement of the hand than by rigid opposition.

At the moment of the descent of the internal foot, the horny sole, which you will remember is concave toward the ground surface, becomes slightly flattened, as the result of which no bruising of the delicate structures converging the sensitive foot is incurred.

If we place a foot rule in such a position that one arm is resting on the ground, while the other is lying parallel to the wall of the foot at the toe, and in this position lift up the opposite foot so as to throw double weight on the one under investigation, it will be found that at the moment the extra weight comes on the limb the upper or coronary edge of the hoof slightly recedes from the foot rule; when the extra weight is taken off the foot, the edge advances into its original place. This phenomenon is associated with a sinking of the upper edge of the hoof at the heels and an increase in the width of the foot.

The change in shape just described follows as the result of a temporary rearrangement in position of the parts within.

We have previously drawn attention to the very vascular nature of the horse's foot; time will not admit of stopping to inquire into the causes of this vascular condition, but what chiefly strikes the physiologist is that a part lying furthest from the heart should be able to have such a complex circulation carried on with comparative ease. Does the foot in any way assist in its own circulation? The experiment which I am about to show you proves this very conclusively, and demonstrates that a pumping mechanism exists, by which the blood is forced out of the foot every time the weight comes on it.

Into the veins of this foot I have placed two glass tubes, and both are filled with water; by projecting these tubes on the screen you will be better able to observe that at the moment I press on the foot joint—and thereby, as you will remember, depress the internal foot and at the same time cause the whole part to slightly expand—the fluid rises considerably in the manometer tubes; when I remove the pressure the fluid falls. Now in the living foot when the weight comes on the limb, the blood is pumped with considerable force up the veins of the leg, and at every move-

* A number of microscopical preparations were placed on the library table illustrating the structure of the foot. The majority were kindly prepared for this lecture by Professor Mettam, B.Sc. Dick Veterinary College, Edinburgh.

ment this is repeated. That the living foot behaves like our dead one, is proved by the fact that if a vein be divided in the living animal, a jet, as if from a syringe, comes from it every time the foot comes to the ground.

The pumping action in the foot is due to the various movements occurring in this organ, and without their aid it is probable that the circulation in the foot would be carried on with extreme difficulty.

Finally, let us briefly pass in review the changes occurring in the foot from the time it makes contact with the ground until it leaves it.

The weight is received on the posterior part of the foot and foot pad, by which means the plantar cushion resting above the foot pad is altered in shape; the foot pad and plantar cushion being compressed and widened, each exerts pressure on the part of the foot with which it is in contact, so that both the wall of the hoof and the elastic cartilages are pressed out.

CIRRHOPE TALUM ROTHSCILDIANUM, n. sp.

At the meeting of the orchid committee of the Royal Horticultural Society on October 15, the Hon. Walter Rothschild exhibited what was unanimously agreed to be the handsomest of the plume-bearing section of Cirrhopetalum, and under the above name it was awarded a first class certificate—an honor only once before accorded to a member of this singular genus. The plant was received from an explorer somewhere in the hills beyond Darjeeling a few years ago, but owing to its long and slow journey it, together with a few others, chiefly new botanical orchids, arrived in so withered a condition that only this season, after careful nursing, has it succeeded in flowering. As the cultivated pseudo-bulbs are scarcely one-third the size of the imported ones, it is but reasonable to infer that the flowers, beautiful though they are, will still improve as the plant gains strength. The pseudo-bulbs

CIRRHOPE TALUM ROTHSCILDIANUM—FLOWERS BRIGHT PURPLE, WITH YELLOW MARKINGS.

ward, and expansion of the foot occurs. Concurrently with this the weight has been received on the posterior part of the pedal joint with its yielding articulation formed by the navicular bone. By the time the whole foot is flat on the ground, the entire sensitive foot has become depressed within the horny envelope, the heels of the hoof have sunk, and the coronary edge traveled backward. The body now passes over the foot, the limb revolves as it were around one point, viz., the foot joint, and finally the heels leave the ground, their width becomes decreased, while the final propulsion to the body is given by the toe, which is the last part of the foot to leave the ground.

The hour allotted to this discourse has expired. I have had to take you very hurriedly, and I fear very imperfectly, over a considerable amount of ground, such, indeed, as might have occupied our attention for several lectures, but I trust I have awakened an interest in a very important subject, and that something may have fallen from me which will be of use to you and to that animal to which we are all so much attached.

vary in form from ovate to pear-shaped, each bearing a single fleshy light green leaf, more or less distant on the rhizomes. Scape erect, 8 inches in height, bearing at the top a one-sided umbel of flowers, each over 6 inches in length, and exceeding one inch across the broadest part of the lower sepals. The prevailing color of the flowers is bright crimson purple, some blotches of clear yellow appearing on the sepals. The cucullate upper sepal is yellow with purple lines, and with marginal fringe and a very sensitive plume of a purple color at the apex. The petals are narrower, but similarly colored and decorated. The lower sepals show little other color than rich crimson purple, the same hue pervading their slender tail-like appendages which sometimes intertwine and at others are free. The triangular, grooved, hinged labellum is purple, and the whole flower so remarkably attractive as to command attention even from those who profess to care for nothing but the showiest orchids. Its nearest affinity seems to be *C. Collettii*, Hemsl.—The Gardeners' Chronicle.

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TABLE OF CONTENTS.

	PAGE
I. BIOGRAPHY.—Alfred E. Beach.....	16693
Alexandre Dumas.—The younger Dumas.—Notes on his life and works, with portrait.—1 illustration.....	16706
Chiefs of the First Cuban Revolution.—Portraits of three of the Cuban leaders, with notes on their lives.—3 illustrations.....	16706
II. CIVIL ENGINEERING.—Roy Stone's Report to Secretary Morton on American Roads.—One of the great questions of the present day considered in a government report, with data and figures of expense.....	16700
III. ENTOMOLOGY.—The Transformations of Insects.—An exhaustive paper on the metamorphoses of insect life.—First installment of the article.....	16707
IV. FISH CULTURE.—Our Fishes and Fisheries.—Notes on the last report of the United States Commissioner of Fish and Fisheries.....	16706
V. HORTICULTURE.—Cirrhopetalum Rothschildianum, n. sp.—A curious and beautiful certificated orchid of the plume bearing type.—1 illustration.....	16710
VI. HYGIENE.—The Special Rules for Dangerous Occupations.—Rules for observation by employees in different classes of dangerous occupations, such as those followed in chemical factories.....	16695
VII. METALLURGY.—Copper Refining by Electricity.—Electro deposition applied to the production of almost chemically pure copper on a large scale.....	16698
Notes on Gold Mining in California.—Assaying and sampling of ores in order to obtain correct average results.—7 illustrations.....	16702
VIII. MECHANICAL ENGINEERING.—Steam Pipe Isolating Valve.—2 illustrations.....	16699
IX. MISCELLANEOUS.—Strawbe Bedfellows.—Curious friendship between a honess cub and dog.—1 illustration.....	16707
X. GUNNERY.—The Blake Electric Rifle.—A gun operated by an electric battery, giving a spark discharge through the powder.—1 illustration.....	16698
XI. PHOTOGRAPHY.—Manufacture of Photographic Paper.—A valuable paper on the manufacture of bromide paper at the famous Lumiere works.—4 illustrations.....	16695
XII. PHYSIOLOGY.—The Perception of Light.—A review by a physicist of the subjective aspect of light.—How vision operates.....	16701
XIII. POLITICAL ECONOMY.—The Legal Merits of Venezuela's Case.—A conservative and well thought out paper on this subject.....	16705
XIV. RAILROAD ENGINEERING.—Air Brake Equipment.—A recent paper read before the New England Railroad Club, giving a practical view of the air brake as applied to freight cars and other rolling stock.....	16699
High Speeds in the United States.—An English view of the high speed train records claimed in the United States, with special reference to the recent work on the Lake Shore and Southern Railroad.....	16700
XV. TECHNOLOGY.—Commercial Fibers.—By D. MORRIS.—Lecture III.—Brush and mat fibers.—Monkey bass.—Continuation of this exhaustive series of lectures, treating principally of bass and similar fiber.—5 illustrations.....	16696
The Chemistry of Oxides Used in the Mantles for Incandescent Lighting.—A chemical-technical review of the composition of the Welsbach burner mantles.....	16704
XVI. VETERINARY SCIENCE.—The Structure and Function of the Horse's Foot.—A most exhaustive review of the anatomy of the horse's foot and the functions of its different parts.—Of value to all horsemen.....	16708

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