sons, of moderately spare frame, with sound viscera and temperate habits, can sustain great heat, if the atmosphere be pure and moderately dry. Fresh arrivals in India are more prone to suffer than those who have become accustomed to the climate and have learned how to protect themselves. A native can bear an amount of sun on his bare head and naked body with indifference that would prostrate an European; but, when the temperature rises above a certain point, all succumb, and natives suffer and die like others.

Tolerance of heat depends much on the vigour of constitution and actual state of health. The refrigerating powers of the body in health enable it to support a temperature considerably above that of the blood. In the hot winds, little inconvenience is felt so long as perspiration is free; but, when that fails, suffering ensues, and the danger is great.*

Of those who recover, or rather who do not die, many remain invalids for life, which is frequently shortened by obscure cerebral or meningeal changes, which affect the sufferer in various degrees of intensity. Irritability, impaired memory, epilepsy or epileptiform attacks, headache, mania, partial or complete paraplegia, or blindness, and extreme intolerance of heat, especially of the sun's rays, rendering the person incapable of serving in hot climates or of enduring any exposure to the sun; or it may lead to gradually complete fatuity, dementia, or epilepsy; chronic meningitis, with thickening of calvaria, which may account for the intense cephalalgia; or, in a lesser degree, in disordered innervation and general functional derangement, which seriously compromise health.

In cases where death has occurred suddenly from exhaustion, there is no very remarkable morbid change. The heart may be contracted, but often flaccid. The lungs, brain, and membranes may be congested, but they are sometimes the reverse. The venous trunks, especially those of the abdomen, and the right side of the heart, may be filled with blood, which is dark, grumous, imperfectly coagulated, and effused in patches of ecchymosis, rendering the body rapidly livid. Coagulability is impaired, and it is deficient in oxygen.

In death from thermic fever, the lungs are often (not always) deeply congested; the heart is contracted by coagulation of myosin, and the whole venous system is engorged. The body, even before death, may be marked by petechial patches and extensive livid ecchymosis. The blood is generally more fluid than natural, and acid in reaction. The globules are sometimes crenated, and have a diminished tendency to form into rouleaux. The body for some time after death retains a high temperature. When opened, the viscera feel pungently hot. Rigor mortis comes on very rapidly. The brain and membranes may be congested; in some cases, there are evidences of cerebral hæmorrhage and serous effusions in the ventricles.

Treatment.—In cases of simple exhaustion, remove the person to a cooler place. Give a douche, but not too prolonged, or it may depress; remove tight and oppressive clothing, apply ammonia to the nostrils, etc. Enjoin rest, and avoid exposure to over-fatigue or to great heat. When the person is struck down suddenly by the sun, remove him into the shade, and let a douche of cold water fall on his head and body. At the capture of Rangoon, in 1853, numbers of men struck down by the fierce April sun were so treated, and only two, who had been bled, died.

When I say such cases recover, I refer to the reaction at the time. In some, there are consecutive symptoms of fever, headache, etc.; could we trace their subsequent history, it is probable we should find that complete recovery never occurred.

Future exposure to the sun should be carefully guarded against; the sufferer should be removed to a cooler climate, and protected from excitement; whilst the greatest care is taken to avoid errors or excesses of diet and stimulants.

In thermic fever, the object is to reduce temperature as speedily as possible before tissue changes take place. The use of quinine by hypodermic injection has been thought to produce good results by reducing temperature. It was first used, I believe, by Dr. Waller in Calcutta.

Bleeding has been abandoned, except in rare cases. There are cases in which it may be necessary to avert suffocation, but they are exceptional. Where it has appeared to give relief, the improvement has generally been transient, and followed by relapse into a more dangerous and fatal condition.

* In the Fourteenth Annual Report of the Sanitary Commissioner with the Government of India, 1877, it is stated that 235 cases of heat-apoplexy and sunstroke occurred in the army in India, of which 70 were fatal. The admission rate (4.1) is almost the same as in 1876, and exactly the same as in 1865. The death-rate (1.22) is below the average of the last six years. Of the 235 cases, 189 occurred during the four months of May to August. The disease was widely spread. 1 gives rise to a fatality of 12.2 per cent. in the first and second years of the European soldier's service in India. The deaths per 1,000 strength:—Service: 1 to 4 years, 1.48; 5 to 7 years, 1.05; above 7 years, 1.50. Age: Under 25, .65; 25 to 29, .99; 30 and upwards, 2.33.

The application of cold by affusion, or by ice, taking care not to reduce the temperature too low, is beneficial, a thermometer being placed as a guide in the axilla or rectum. The bowels should be relieved, and cooling drinks given. The most severe symptoms having subsided, the febrile condition is to be treated on ordinary principles; the diet must be carefully regulated. As improvement progresses, and symptoms of intra-cranial mischief supervene, iodide of potash and counter-irritation may be of service; removal to a cooler climate is essential. As a general rule, it is desirable that the sufferer should not return to a hot climate, and he should be guarded against all exposure to heat, overwork, and anxiety.

In simple cases of sun fever (which are not to be confused, as they often are, with insolation), where the reaction is not excessive, the treatment is that of ordinary ephemeral fever.

Continued Fever.—Writers on Indian and tropical disease have described a form of continued fever liable to be modified by visceral complications, and to terminate fatally,—*post mortem* examination revealing pathological changes of various degrees of importance. It is attributed to circumstances attending life in tropical or subtropical regions—such as heat, atmospheric vicissitudes, terrestrial emanations, personal habits, no very distinct characters differentiate it from remittent, which has assumed a continued form. Twining, Annesley, Martin, and others, regarded it as a variety of malarial fever, in which perhaps there is little difference of opinion. But perhaps it is necessary to distinguish it from specific continued fevers, with which it may be confounded. In typical cases of remittent, the diagnosis is clear enough; but in many it is difficult, if not impossible: for the characters of the temperature curve vary so little that it is not a sure guide. Other fevers in India may assume this condition, especially if not dealt with properly at first; and visceral complications are generally, if not always, the precursors and concomitant of the change of type.

[To be continued.]

THE LUMLEIAN LECTURES ON INFLAMMATION.

Delivered before the Royal College of Physicians.

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LECTURE III. PART II.—ETIOLOGY OF INFLAMMATION.

WE have now, I think, clearly before us the phenomena of the inflammatory afflux. It so resembles a reflex action, in the way in which the vessels of an irritated part respond to the stimulus, that the view which must naturally suggest itself is that of its reflex nature. To come to a conclusion as to whether it is so or not, let us first look at the question from the purely physiological side. There are vascular reactions which resemble the inflammatory very strikingly in their character, about which we know that they are reflex. To what extent does that similarity indicate identity of mechanism? One of the best known of these instances is that of the submaxillary gland. In 1851, it was discovered by Claude Bernard (*Leçons sur la Physiologie et la Pathologie du Système Nerveux*. Paris, 1858, vol. ii, page 144), that the influence of the lingual nerve on the secretion of that gland, which Ludwig had made known by his experiments in 1851, is really due to the chorda tympani; and that this remarkable nerve has two distinct afferent functions: that, on the one hand, it presides over the secretion of the gland; on the other, over the circulation of blood through its vessels—in such a way that, when the chorda tympani is excited electrically, the gland reddens; vessels, before invisible even with a lens, become easily distinguishable; the veins fill with blood (which, instead of being crimson, is scarlet), pulsate like arteries, and, if cut, spirt also like arteries.

Now it is quite clear what John Hunter would have thought of this experimental fact, if he had seen it. He would have at once recognised its analogy to the inflammatory flush, and would have explained it by reference to what he called a "common principle in the animal machine"—namely, that vessels become large in proportion to the necessity of supply. In the sixty years that had passed since his death, that idea of Hunter had developed into the doctrine of what was called vital attraction—the doctrine that the distribution of the blood to different parts of the body, or to different organs, is determined

by the attraction for the blood which the tissues were supposed to exercise. This doctrine was present to all physiologists at that time, and led Bernard to make various experiments, for the purpose of determining the physiological relation between the two effects observed—namely, increased secretion, and the flush which accompanied it. From the fact that these effects were not really simultaneous, the vascular effects being seen earlier than the increased secretion, he inferred that they were independent; but this was not proved until Heidenhain ("Ueber die Wirkung einiger Gifte auf die Nerven der Glandula Submaxillaris," Pflüger's *Archiv*, vol. v, page 309), profiting by the remarkable property of the alkaloid atropine, in annulling the function of secreting nerves, showed that in an atropinised animal (that is, an animal in which atropine enough had been injected into the circulation to paralyse the secreting mechanism), vascular congestion of the submaxillary gland could be excited, either reflexly or directly, without stimulating it to increased secretion.

Here, then, was a case which might be strictly compared with the inflammatory blush, for it was unmixed with any other physiological effect. To this first example of determination of blood to a part, directly dependent on central influence, many others might now be added from the records of experimental physiology. I will mention only one of them, and that chiefly on the ground that it seemed to offer a rather plausible explanation of the phenomenon which now engages our attention. I refer to the experiments ("Ueber die Erweiterung von Arterien in Folge einer Nervenregung," Ludwig's *Arbeiten*, 1866, pp. 1-29), of Professor Christian Löwen of Stockholm, with whose charming personal qualities we had many of us an opportunity of becoming acquainted last August. What Löwen discovered was that, under certain easily realised conditions, an active congestion of the rabbit's ear, as intense as the paralytic hyperæmia of Bernard and Brown-Séquard, observed after section of the vascular nerves of that organ, could be determined reflexly—that is, by stimulation of its sensory nerves; and that, in other parts of the surface of the body, similarly localised hyperæmia could be produced by localised stimulation.

I have referred to these instances of reflex dilatation of the blood-vessels in the most cursory way, because, in reality, their bearing on the question immediately before us is only indirect. The really important fact that we learn from them is, that some mechanism exists in the blood-vessels of such a kind as to suggest active dilatation; for, in all of them, we see that a few seconds after a stimulus, of which the influence is received, whether reflexly or directly through a cranial or spinal nerve, the vessels dilate. Now, at a period not very remote from the present, such an action appeared to a great many physiologists impossible—it seemed impossible, I mean, that a blood-vessel could be acted upon by stimulating its nerves otherwise than to produce contraction of its calibre; for the simple and obvious reason that, in arteries, neither the ring fibres nor the longitudinal fibres could, by their contraction, produce such an effect, and because no other mode of action of a muscular structure, excepting contraction, could be recognised. The difficulty was regarded as so serious that the experimental proof, given long ago by Schiff (*Untersuch. über Physiol. des Nerven-Systems*, 1855, page 140), that there were such things as dilating nerves, was accepted with the utmost unwillingness. Now, we are convinced of the fact, that the nerves of muscles of the external parts of our bodies generally dilate, under the same conditions that the vessels of our viscera contract; and we recognise, in this antagonism* between outside and inside, a factor of great importance in the adaptation of the circulation of blood to the needs of the organism. But, as I have already hinted, for reasons which are easily stated, we must not allow ourselves to be misled by the apparent analogy of such effects as, *e. g.*, that of the reflex congestion of the ear of the rabbit produced by stimulation of its sensory nerves, into supposing that they have the same meaning as inflammatory congestion.

One reason is that of time. I have more than once spoken of the inflammatory blush as transitory. The meaning of such a word as

transitory is relative. As compared with inflammatory congestion, it is transitory; but, compared with a reflex response (such as occurs in the rabbit's ear, or in the submaxillary gland), it is lasting. The one is a question of minutes, the other of seconds. But the really conclusive reason why we are absolutely certain that the Hunterian effect is not dependent on, though it is influenced by, the brain or spinal cord, is, that it occurs in all perfection in paralysed parts. It is a very long time since Mr. Simon (*Lectures on General Pathology*, 1850, page 76) observed, in a patient whose eye was anæsthetic in consequence of disease affecting the fifth nerve, that, when a grain of irritant substance was introduced underneath the upper eyelid, the conjunctiva became at once hyperæmic, although the patient felt absolutely nothing. This observation of Mr. Simon's was perhaps the earliest of the kind. However that may be, the truth of its teaching has been abundantly confirmed since. In the frog, it is a matter of no great difficulty to ligature the root of the tongue in such a way as to exclude the blood-vessels. If this be done, the circulation, of course, goes on naturally, and you may observe it on the smooth surface, under the microscope, as Waller did. If, while you are doing so, the surface be touched with a hot wire, it responds with a blush, just as the normal tongue does.

Side by side with these facts, may be placed those which show that paralysed arteries respond to stimuli which act on them through the blood which circulates through them. The organ best adapted for showing this is the kidney. Half-a-dozen years ago, Dr. Mosso (Von einigen neuen Eigenschaften der Gefässwand, Ludwig's *Arbeiten*, 1874, p. 156) discovered that, when artificial circulation is maintained through an excised kidney, under constant conditions as regards the pressure and temperature of the blood, the rate of flow through the organ undergoes variations which manifest themselves in changes of volume, and are due to the independent action of its arteries. Starting from these facts, Dr. Roy of the Brown Institution (*Transactions of the Cambridge Philosophical Society*, July 1881) has carried our knowledge of kidney-innervation much further. He has investigated with the utmost minuteness the mode in which the arteries of the living kidney respond to a variety of conditions affecting them through the blood with which they are supplied; and has proved, among other important facts, that the effect of certain diuretic remedies, which is due to the direct dilating influence on the renal arteries, is as well marked after all the renal nerves have been divided as in the normal kidney. It is clear, therefore, that the arteries possess physiological endowments of a remarkable kind independently of the nervous system. The next question is, How do they act? And, to get at this, we must briefly consider what the normal state of the arteries is; and, inasmuch as our object is to eliminate the influence of the central nervous system, we must confine our inquiries to arteries from which the channels of cerebro-spinal influence have been cut off. When, by the nearly simultaneous discoveries of Bernard, Brown-Séquard, and Augustus Waller, the fact first became known that the arteries of organs of which the vaso-motor nerves were divided became enlarged, it was supposed that the state of paralysis was permanent. In short, as Brown-Séquard said in 1851, motor nerve is to muscle what vaso-motor nerve is to artery. Not many years later, Schiff discovered what everyone is now familiar with, that the paralysed artery recovers, and sometimes even recovers its normal state of contraction, or, as we call it, its tonus. Tonus, therefore (by which I mean simply that the artery, when subjected to the internal pressure to which it is accustomed, is of its natural size), is one of the independent endowments of arteries. Another endowment is that of rhythmical contraction. Everyone has watched the rhythmical contraction of the arteries of the rabbit's ear. A few have, perhaps, seen the corresponding phenomenon first observed by Mr. Wharton Jones in 1852*—the slow pulsation of the veins in the wing of the bat. At that time, vaso-motor nerves were not known. When they were discovered, the influence of section was tried, and it was thought that these pulsations ceased. It is, indeed, only by experiments made during last year (Luchsinger, von den Venenherzen in der Flughaut der Fledermause, Pflüger's *Archiv*, vol. xxvi, p. 445) that we know that these rhythmical movements are absolutely independent; for, if the circulation be maintained artificially, the rhythmical motions continue for many hours after the death of the animal. The evidence we thus derive from the manifestation in paralysed vessels of these two physiological endowments—namely, tonus and rhythmical action—that such vessels are in a functionally active state, naturally leads us back to the notion entertained by some of the older physiologists, that the relation of the arteries to the central nervous system is similar to that of the heart. Of this similarity there can be no question. Of the blood-vessels it can be stated as truly as of the heart, that their tonus is capable of being influenced by the cerebro-spinal nervous system in

* The first step towards the discovery of this antagonism was made in 1870 by Heidenhain ("Ueber bisher unbeachtete Einwirkungen des Nerven-Systems," etc.; Pflüger's *Archiv*, vol. iii, p. 504), who found that increased action of the vasomotor centre, however produced, led to increased vigour of the circulation and to increased temperature of superficial parts, notwithstanding the arterial constriction which, until then, had been regarded as the sole effect of such action. This observation had results comparable in importance to the first discovery of the vasomotor nervous system; for, by suggesting that the regulatory influence of the brain and spinal cord on the blood-vessels was more complicated and more perfect than had before been imagined, it led to those later investigations too numerous to mention (Goltz, Gaskell, Heidenhain, Vulpian, Stricker, etc.), by which it has been learnt that vascular nerves differ in function not only according to the vessels to which they are distributed, but according to the physiological states of those vessels. Vast as is the work which has been accomplished in this line of investigation since 1870, it is but the introduction to what has still to be done.

* Discovery that the veins of the bat's wing are endowed with rhythmical contractility. *Philosophical Transactions*, 1852.

opposite directions, according to the channels through which the influence is conducted; and, secondly, that they perform their functions in an orderly and natural manner after complete severance of the nervous system. For the same reasons, therefore, and in the same sense that we familiarly regard the action of the heart as automatic, notwithstanding that its motions are at every moment influenced and regulated by the central nervous system, we are justified in saying that the blood-vessels also act automatically and *proprio motu*. If we had to do with a single artery, we might reason from one to the other, and venture on the analogy so far as to anticipate that, whenever the key shall be discovered to the wonderful controlling influence exercised by the central nervous system on the heart through the vagus, the same key will be found to serve for the solution of the equally difficult problem of the influence of these centres on the blood-vessels. But, if we resort to the phenomenon on which we are now endeavouring to throw light—that of the inflammatory *affluxus sanguinis*—we are at once reminded that, as regards the vessels, there is something else to be considered, of which the physiology of the heart affords us no counterpart. When one puts a little bit of nitrate of silver on the nerveless tongue of a frog, or when a bit of dust is introduced under a feelingless eyelid, the effect starts from the irritant, and rapidly spreads over the surface from vessel to vessel with considerable rapidity. How do we account for this co-ordinated action where the controlling influence of the nervous system is cut off? You know the answer that Lister made to this question in 1858. He met it by the hypothesis of a peripheral nervous system, or, as he called it, “a local co-ordinating apparatus.....capable of being independently influenced by irritation,” though normally “in subordination to the nervous system.” These notions of Lister’s, neglected and forgotten for fifteen years, have now become familiar; for, by elaborate researches made chiefly during the years 1874-78, of which Goltz was the initiator, the independent action of the arteries of the external parts of the body has been established, and it has since become the habit of physiologists to talk of “peripheral local centres” for these vessels as if such things really existed. I need not say that there is no more anatomical evidence now that such things exist, than there was when Lister first called them into being in order to vest in them the local management of the vascular system. The question whether such machinery is necessary or not, is one which we need not at present determine; nor does it in the slightest degree affect the pathological application of the firmly established and universally accepted conclusion that, centres or no centres, the peripheral arteries are able to act in concert with each other, even when they are deprived of the regulatory influence of the brain and spinal cord.

And thus we find ourselves once more coming back to the notions, which at one time were thought obsolete, of the great father and founder of physiological pathology, JOHN HUNTER—accounting for the inflammatory blush, which he was the first to describe, by attributing it, as he did, to the “action of the vessels”.

ABSTRACT OF LECTURES

ON THE

MORPHOLOGY OF THE MAMMALIAN SKULL.

Delivered at the Royal College of Surgeons of England.

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LECTURE IX.—CONTINUATION OF SUBJECT OF LECTURE VIII, AND CONCLUSION.

TURTLES, Crocodiles, and Birds all bring the cranial architecture almost to the level of that of the lower Mammalia; but this is best seen in Crocodiles. The intense solidity of the face and cranium in the latter, the thick bones fitting by clear sutures, and especially the extensive desmognathism of the palatal region—which is in excess of that seen in most mammals, only existing again in some Edentata and Cetacea—all show this. But the Crocodile’s skull is essentially sauropsidan, and is distinguished from that of the lowest known mammal by the distinctness of the quadrate between the mandible and the head, by the full development of the movable lower jaw, by the absence of a proper malleus in the ear-chain, and by the arrest of the cochlea, and the rudimentary condition of the turbinal growths of the nasal capsule.

The characters of the Mammalian skull are as follows.

1. There are no superficial prefrontal or postorbital bones.
2. The jugal arch is not finished by a quadrato-jugal.
3. The occipital condyles are double.
4. The periotic bones unite with each other early, and join very little with the surrounding bones.
5. The inferior turbinals are well developed, and the hinder and upper nasal (or true olfactory) region is full of turbinal outgrowths.
6. The lower jaw of the adult is composed of only one piece on each side, and each ramus articulates directly with the skull by means of the squamosal.
7. The auditory chain is composed of three main segments, instead of two, as in the Sauropsida; for the hinder part of the lower jaw is arrested very early to form the malleus, the new and foremost bone of that chain.
8. The permanent functional lower jaw is formed of both a superficial cartilage and a superficial bone; so that it does not correspond simply to the fore-half of the mandible of the sauropsidan.
9. The epihyal end of the functional hyoid early coalesces with the opisthotic (mastoid), the stylo-mastoid foramen opening just over and behind that junction; the chorda tympani, or anterior branch of the seventh nerve, escapes from the bony tunnel in which the main nerve runs, and passes over the incus.
10. Besides the stapedius muscle, there is a tensor tympani, which only exists as an adductor of the mandible in the Sauropsida.
11. The ear-drum is finished externally by both a superficial cartilage (*bullæ*) and a superficial bone (*tympanic*) of the opercular category; both these lie internal to the concha.

These are some of the most evident specialisations seen in the adult mammalian skull, which sharply distinguish it from that of an adult sauropsidan. But that which strikes the eye most is that, whilst in the Sauropsida, as also in Lepidosteus, there are six bony pieces in each ramus of the mandible, there is only one in that of the mammal, and this articulates directly with the skull-wall; and also that there is a new element in the ear-chain.

No gradational study of adult skulls is of any service here; and the palæontological record sheds no light upon the subject. The only known fossil mammals from the lower secondary strata are marsupials, and are of a far higher type than the existing Australian monotremes; and yet these latter are truly mammalian in their skulls.

Embryology is our only resource at present; and it reveals the secret of this divergence, seen in the adult condition of the Sauropsida on the one hand, and the Mammalia on the other. In the early development of the skull and face, there is an essential conformity between these two; and in those parts which undergo most modification afterwards, the only primary difference in the newly chondrified bars is, that in the Mammalia—even in the lowest orders—the quadrate segment or pier of the mandible is only partially marked off from the rest of the arch.

We have, therefore, in the early cartilaginous state of the mammalian visceral arches, a mandibular bar which has an upper knob answering to the distinct quadrate of the reptile or bird, which has a larger internal, and a lesser posterior angular process—quite sauropsidan in character.

In the next arch, the pharyngo-hyal again is in two pieces: one, the stapes, fits into the fenestra ovalis; and the other, the incus, is articulated to the stapes behind and to the knobbed head of the mandibular bar—which will give rise to the malleus—in front.

Passing from the distal part of the stapes, there is, in many cases, a small segment of cartilage which answers to the interhyal of the crocodile, and to the infrastapedial bar of the lizard and bird. This remains distinct for a time, and is bound up with the tendon of the stapedius, which muscle passes inside the top of the main hyoid bar, to be inserted fleshy in the hinder tympanic recess. The rest of the hyoid bar is subdivided much as in a normal branchial arch, as in the crocodile; but it does not attach itself, as in that type, to the mandible.

Now, in the Sauropsida generally, the pier of the lower jaw has the squamosal as its proper investing bone; whilst the articulo-meckelian bar, or free lower jaw, has six membrane bones on each ramus, the last of which, the articulare, unites early with the ossifying articular end of the mandible. This state of the ramus is quite like what is seen as low down as in Lepidosteus. The splints that remain distinct are the dentary, the splenial, and coronoid in front, and the supra-angular and angular behind. The rod-like distal end of Meckel’s cartilage is mostly absorbed, and does not take any active part in forming the fore part of the ramus; for a time, in Chelonina and Crocodilia, the two are united distally by a non-segmented basi-mandibular plate of cartilage.

In the lower types of Mammalia, especially in Ornithorhynchus and