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# LVII. On the sivatherium giganteum, a new fossil ruminant Genus, from the valley of the markanda, in the sivâlik branch of the sub-himálayan mountains

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of the tension of elastic membranes in modulating the tones produced by them has been very satisfactorily demonstrated by the interesting experiments of Savart*, and it is no doubt materially concerned in the analogous phænomena of the voice. The diameter of a tube does not influence the pitch of its sound, but there is an obvious appropriateness in the diminution of the diameter of the trachea as the sound becomes sharper; for experience has taught the makers of wind instruments that the best qualities of tone for the lower notes are obtained when the bore of the instrument is large, and for the higher notes when it is small.

The influence of the vocal tube, as far as relates to its effects on the key of the voice, is terminated at the *velum palati* by the several perforations of the nostrils, the Eustachian tubes, and the mouth. The opinion of Savart, that the mouth modifies the key of the tone is consequently erroneous †.

We find analogous acoustic effects in musical instruments; for instance, the lowest joint of the flute, which is six inches in length, having three perforations, when its keys are open lowers the tone of the instrument only half a note. The important distinction between the effects of air passing through the tubes of musical instruments, according as their sides are rigid or membranous, is, that in the former case, as exemplified in flutes, hautboys, &c., the air vibrates independently of the sides of the tube, whilst in the latter, the tube enters into compound vibrations with the column of air.

[To be continued.]

## LVII. *On the* Sivatherium giganteum, *a new Fossil Ruminant Genus, from the Valley of the Markanda, in the Sivâlik branch of the Sub-Himâlayan Mountains. By* Hugh Falconer, *M.D., Superintendent Botanical Garden, Sehâranpur, and Captain* P. T. Cautley, *Superintendent Doâb Canal.*

[Continued from p. 201, and concluded.]

NOTWITHSTANDING the singularly perfect condition of the head, for an organic remain of such enormous size, we cannot but regret the mutilation at the muzzle and vertex, as it throws a doubt upon some very interesting points of structure in the *Sivatherium*: 1st, the presence or absence of incisive and canine teeth in the upper jaw, and their number and character if present; 2nd, the number and extent of the bones which enter into the basis of the external nostrils; and 3rd, the presence or absence of two horns on the vertex, besides the two intra-orbital ones.

* *Annales de Chimie.*

† Tandis que la bouche en s'ouvrant plus ou moins, et en changeant par consequence les dimensions de la colonne d'air, exerce aussi une influence notable sur le nombre des vibrations, conjointement avec les lèvres.—*Ann. de Chimie*, 1825.

Regarding the first point, we have nothing sufficient to guide us with certainty to a conclusion, as there are ruminants both with and without incisives and canines in the upper jaw; and the *Sivatherium* differs most materially in structure from both sections. But there are two conditions of analogy which render it probable that there were no incisives. 1. In all ruminants which have the molars in a contiguous and normal series, and which have horns on the brow, there are no incisive teeth. In the camel and its congeners, where the anterior molars are unsymmetrical and separated from the rest of the series by an interval, incisives are present in the upper jaw. The *Sivatherium* had horns, and its molars were in a contiguous series: it is therefore probable that it had no incisives. Regarding the canines there is no clue to a conjecture, as there are species in the same genus of ruminants both with and without them. 2. The extent and connexions of the incisive bones are points of great interest, from the kind of development which they imply in the soft parts appended to them.

In most of the horned *Ruminantia*, the incisives run up by a narrow apophysis along the anterior margins of the maxillary bones, and join on to a portion of the sides of the nasals; so that the bony basis of the external nostrils is formed of but two pairs of bones, the nasals and the incisives. In the camel, the apophyses of the incisives terminate upon the maxillaries without reaching the nasals, and there are three pairs of bones to the external nostrils, the nasals, maxillaries, and incisives. But neither in the horned ruminants, nor in the camel and its congeners, do the bones of the nose rise out of the plane of the brow with any remarkable degree of saliency, nor are their lower margins free to any great extent towards the apex. They are long slips of bone, with nearly parallel edges, running between the upper borders of the maxillaries, and joined to the ascending process of the incisive bone, near their extremity, or connected only with the maxillaries; but in neither case projecting so as to form any considerable re-entering angle, or sinus, with these bones.

In our fossil, the form and connexions of the nasal bones are very different. Instead of running forward in the same plane with the brow, they rise from it at a rounded angle of about 130°, an amount of saliency without example among ruminants, and exceeding what holds in the rhinoceros, tapir, and palæotherium, the only herbivorous animals with this sort of structure. Instead of being in nearly parallel slips, they are broad and well arched at their base, and converge rapidly to a sharp tip, which is hooked downwards, over-arching the external nostrils. Along a considerable portion of their length they are unconnected with the adjoining bones, their lower margins being free and so wide apart from the maxillaries as to leave a gap or sinus of considerable length and depth in the bony parietes of the nostrils. The exact extent to which they are free, is unluckily not shown in the fossil, as the anterior margin of the maxillaries is mutilated on both sides, and the connexion with the incisives destroyed. But as the nasal bones shoot forward beyond the mutilated edges of the maxillaries, this circumstance, together with their well-defined outline and symmetry on both sides of the fossil, and their rapid convergence to a point with some convexity, leaves not a doubt that they were free to a great extent and unconnected with the incisives.

Now to determine the conditions in the fleshy parts, which the structure in the bony parietes of the nostrils entails.

The analogies are to be sought for in the *Ruminantia* and *Pachydermata*.

The remarkable saliency of the bones of the nose, in the *Sivatherium*, has no parallel, in known ruminants, to guide us; and the connexion of the nasals with the incisives, or the reverse, does not imply any important difference in structure in the family. In the Bovine section, the Ox and the Buffalo have the nasals and incisives connected: whereas they are separate in the Yák* and Aurochs. In the Camel, they are also separate, and this animal has greater mobility in the upper lip than is found in other ruminants.

In the *Pachydermata*, both these conditions of structure are present and wanting in different genera; and their presence or absence is accompanied with very important differences in the form of the corresponding soft parts. It is therefore in this family that we are to look for an explanation of what is found in the *Sivatherium*.

In the Elephant and Mastodon, the Tapir, Rhinoceros, and Palæotherium, there are three pairs of bones to the external nostrils; the nasals, the maxillaries, and incisives †. In all these animals, the upper lip is highly developed, so as to be prehensile, as in the Rhinoceros, or extended into a trunk, as in the Elephant and Tapir; the amount of development being accompanied with corresponding difference in the position and form of the nasal bones. In the Rhinoceros, they are long and thick, extending to the point of the muzzle, and of great strength to support the horns of the animal; and the upper lip is broad, thick, and very mobile, but little elongated. In the Elephant, they are very short, and the incisives enormously developed for the insertion of the tusks, and the trunk is of great length. In the Tapir, they are short and free, except at the base, and projected high above the maxillaries; and the structure is accompanied by a well-developed trunk. In the other pachydermatous genera, there are but two pairs of bones to the external nostrils, the nasals and the incisives: the latter running up so as to join on with the former; and the nasals, instead of being short and salient, with a sinus laterally between them and the maxillaries, are long, and run forward, united to the maxillaries, more or less resembling the nearly parallel slips of the *Ruminantia*. Of this genera, the Horse has the upper lip endowed with considerable mobility; and the lower end of the nasals is at the same time free to a small extent. In all the other genera, there is nothing resembling a prehensile organ in the upper lip.

In the *Sivatherium*, the same kind of structure holds as is found in the *Pachydermata* with trunks. Of these it most nearly resembles the Tapir. It differs chiefly in the bones of the nose being larger and more salient from the chaffron; and in there being less width and depth to the naso-maxillary sinus, than the Tapir exhibits. But as the essential points of structure are alike in both, there is no doubt that the *Sivatherium* was invested with a trunk like the Tapir.

This conclusion is further borne out by other analogies, although more indirect than that afforded by the nasal bones.

1st.—The large size of the infra-orbitary foramen. In the fossil, the exact dimensions are indistinct, from the margin having been injured in the chiseling off of the matrix of stone: the vertical diameter we make out to be 1·2 inch, which perhaps may be somewhat greater than the truth; but anything approaching this size, would indicate a large nerve for transmission, and a highly developed condition of the upper lip.

2nd.—The external plate of the bones of the cranium is widely separated from the inner, by an expansion of the diploe in vertical plates, forming large cells, as in the cranium of the Elephant: and the occipital is expanded laterally into alæ, with a considerable hollow between, as in the Elephant. Both these conditions are modifications of structure, adapted for supplying an extensive surface for muscular attachment, and imply a

* Cuvier, *Ossemens Fossiles*, tome iv. p. 131. † *Ibid.*, tome iii. p. 29.

thick fleshy neck, with limited range of motion; and, in more remote sequence, go to prove the necessity of a trunk.

3rd.—The very large size of the occipital condyles, which are greater both in proportion, and in actual measurement, than those of the Elephant, the interval between their outer angles, taken across the occipital foramen, being 7·4 inches. The atlas, and the rest of the series of cervical vertebræ, must have been of proportionate diameter to receive and sustain the condyles, and surrounded by a large mass of flesh. Both these circumstances would tend greatly to limit the range of motion of the head and neck. But to suit the herbivorous habits of the animal, it must have had some other mode of reaching its food; or the vertebræ must have been elongated in a ratio to their diameter sufficient to admit of free motion to the neck. In the latter case, the neck must have been of great length, and to support it and the load of muscles about it, an immense development would be required in the spinal apophysis of the dorsal vertebræ, and in the whole anterior extremity, with an unwieldy form of the body generally. It is therefore more probable that the vertebræ were condensed, as in the Elephant, and the neck short and thick, admitting of limited motion to the head: circumstances indirectly corroborating the existence of a trunk.

4th.—The face is short, broad, and massive, to an extent not found in the *Ruminantia*, and somewhat resembling that of the Elephant, and suitable for the attachment of a trunk.

Next with regard to the horns:—

There can be no doubt, that the two thick, short, and conical processes, between the orbits, were the cores of horns, resembling those of the Bovine and Antilopine sections of the *Ruminantia*. They are smooth, and run evenly into the brow without any burr. The horny sheaths which they bore, must have been straight, thick, and not much elongated. None of the bicorned *Ruminantia* have horns placed in the same way, exactly between and over the orbits: they have them more or less to the rear. The only ruminant which has horns similar in position is the four-horned Antelope* of Hindustán, which differs only in having its anterior pair of horns a little more in advance of the orbits than occurs in the *Sivatherium*. The correspondence of the two at once suggests the question, "had the *Sivatherium* also two additional horns on the vertex?" The cranium in the fossil is mutilated across at the vertex, so as to deprive us of direct evidence on the point, but the following reasons render the supposition at least probable:

1st.—As above stated, in the bi-cavicorned *Ruminantia*, the osseous cores are placed more or less to the rear of the orbits.

2nd.—In such known species as have four horns, the supplementary pair is between the orbits, and the normal pair well back upon the frontal.

3rd.—In the Bovine section of *Ruminantia*, the frontal is contracted behind the orbits, and upwards from the contraction, it is expanded again into two swellings, at the lateral angles of the vertex, which run into the bases of the osseous cores of the horns. This conformation does not exist in such of the *Ruminantia* as want horns, or as have them approximated on the brow. It is present in the *Sivatherium*.

On either supposition, the intra-orbitary horns are a remarkable feature in the fossil: and if they were a solitary pair on the head, the structure, from their position, would perhaps be more singular, than if there had been two additional horns behind.

Now to estimate the length of the deficient portion of the muzzle, and the entire length of the head:—

* The *Tetracerus* or *Antilope quadricornis* and *Chekara* of authors.

In most of the *Ruminantia*, where the molars are in a contiguous uninterrupted series, the interval from the first molar to the anterior border of the incisive bones is nearly equal to the space occupied by the molars; in some greater, in some a little less, and generally the latter. In other *Ruminantia*, such as the *Camelidæ*, where the anterior molars are insymmetrical with the others, and separated from them by being placed in the middle of the diasteme, this ratio does not hold; the space from the first molar to the margin of the incisives being less than the line of molars. In the *Sivatherium*, the molars are in a contiguous series, and if on this analogy we deduce the length of the muzzle, we get nearly 10 inches for the space from the first molar to the point of the incisives; and 28·85 inches for the whole length of the head, from the border of the occipital foramen to the margin of the incisives; these dimensions may be a little excessive, but we believe them not to be far out, as the muzzle would still be short for the width of the face, in a ruminant.

The orbits next come to be considered. The size and position of the eye form a distinguishing feature between the *Ruminantia* and the *Pachydermata*. In the former it is large and full, in the latter smaller and sunken; and the expression of the face is more heavy in consequence. In the *Sivatherium* the orbit is considerably smaller in proportion to the size of the head than in existing ruminants. It is also placed more forward in the face, and lower under the level of the brow. The rim is not raised and prominent, as in the *Ruminantia*, and the plane of it is oblique; the interval between the orbits at their upper margin being 12·2 inches, and at the lower, 16 2 inches. The longitudinal diameter exceeds the vertical in the ratio of 5 to 4 nearly, the long axis being nearly in a line from the naso-maxillary sinus across the hind limb of the zygomatic circle. From the above we infer that the eye was smaller and less prominent than in existing ruminants; and that the expression of the face was heavier and more ignoble, although less so than in the *Pachydermata*, excepting the horse; also that the direction of vision was considerably forwards, as well as lateral, and that it was cut off towards the rear.

This closes what we have been led to infer regarding the organs of the head. With respect to the rest of the skeleton we have nothing to offer, as we are not at present possessed of any other remains which we can with certainty refer to the *Sivatherium* *. Among a quantity of bones† collected from the same neighbourhood with the head fossil, there are three singularly perfect specimens of the lower portions of the extremities of a large ruminant, belonging to three legs of one individual. They greatly exceed the size of any known ruminant, and excepting the *Sivatherium giganteum*, there is no other ascertained animal of the order, in our collection, of proportionate size to them. We forbear from further noticing them at present, as they appear small in comparison for our fossil: and besides, there are indications in our collection, in teeth and other remains, of other large ruminants, different from the one we have described.

The form of the vertebræ, and more especially of the carpi and tarsi, are points of great interest to be ascertained; as we may expect modifications of the usual type adapted to the large size of the animal. From its

* See note to page 201.—Sec. Asiat. Soc.

† We note here a very perfect cervical vertebra of a ruminant in our possession, which must have belonged to an animal of proportions equal to that of the *Sivatherium*; but from certain characters, we are inclined to suspect that it is allied to some other gigantic species of ruminant, of the existence of which we have already tolerable certainty. Of the existence of the elk, and a species of *Camelidæ*, Lieut. Baker of the Engineers has shown us ample proof.

bulk and armed head, few animals could be strong enough to contend with it, and we may expect that its extremities were constructed more to give support, than for rapidity of motion. But, in the rich harvest which we still hope to reap in the valleys of the *Markanda*, it is probable that specimens to illustrate the greater part of the osteology of the *Sivatherium* will at no very distant period be found.

The structure of the teeth suggests an idea regarding the peculiarities of the herbivorous habits of the animal. In the description it was noticed that the inner central plate of enamel ran in a flexuous sweep, somewhat resembling what is seen in the *Elasmotherium*, an arrangement evidently intended to increase the grinding power of the teeth. It may hence be inferred, that the food of the *Sivatherium* was less herbaceous than that of the existing horned ruminants, and derived from leaves and twigs; or that as in the horse, the food was more completely masticated, the digestive organs less complicated, the body less bulky, and the necessity of regurgitation from the stomach less marked than in the present *Ruminantia*.

The following dimensions, contrasted with those of the elephant and rhinoceros, will afford a tolerably accurate idea of the size of the *Sivatherium*. They are characteristic, although not numerous:—

| | Elephant. | Sivatherium. | Indian 1-horned Rhinoceros. |
|---|---|---|---|
| From margin of foramen magnum to the first molar .................... | 23·10 in. | 18·85 in. | 24·9 in. |
| Greatest width of the cranium ...... | 26·0 | 22·0 | 12·05 |
| Do. do. of face between the malar bones.................................. | 18·5 | 16·62 | 9·20 |
| Greatest depth of the skull........... | 17·80 | 11·9 | 11·05 |
| Long diameter of the foramen magnum | 2·55 | 2·6 | 2·6 |
| Short do. do. do. ...... | 2·4 | 2·3 | 1·5 |
| Average of the above ......... | 15·06 | 12·38 | 10·22 |

If the view which we have taken of the fossil be correct, the *Sivatherium* was a very remarkable animal, and it fills up an important blank in the interval between the *Ruminantia* and *Pachydermata*. That it was a ruminant the teeth and horns most clearly establish; and the structure which we have inferred of the upper lip, the osteology of the face, and the size and position of the orbit, approximate it to the *Pachydermata*. The circumstance of anything approaching a proboscis is so abnormal for a ruminant, that at the first view, it might raise a doubt regarding the correctness of the ordinal position assigned to the fossil; but when we inquire further, the difficulty ceases.

In the *Pachydermata*, there are genera with a trunk, and others without a trace of it. This organ is therefore not essential to the constitution of the order, but accidental to the size of the head, or habits of the animal in certain genera. Thus in the elephant, nature has given a short neck to support the huge head, the enormous tusks, and the large grinding apparatus of the animal; and by such an arrangement, the construction of the rest of the frame is saved from the disturbance which a long neck would have entailed. But as the lever of the head became shortened, some other method of reaching its food became necessary; and a trunk was appended to the mouth. We have only to apply analogous conditions to a ruminant, and a trunk is equally required. In fact, the camel exhibits a rudimentary form of this organ, under different circumstances. The upper lip is cleft; each of the divisions is separately moveable and extensible, so as to be an excellent organ of touch.

The fossil was discovered near the Markanda river, in one of the small valleys which stretch between the Kyárda-dún and the valley of Pinjór, in the Siválik or sub-Himálayan belt of hills, associated with bones of the fossil Elephant, Mastodon, Rhinoceros, Hippopotamus, &c. So far as our researches yet go, the *Sivatherium* was not numerous. Compared with the Mastodon and Hippopotamus (*H. Sivalensis*, Nobis, a new species characterized by having six incisors in either jaw,) it was very rare.

*Northern Doáb, Sept.* 15, 1835.

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## LVIII. *Observations on the Construction of Voltaic Batteries; with a Description of a Battery exhibited at the Royal Institution of Great Britain, June* 3, 1836, *in which an uniform and powerful current is sustained for any period required. By* FRED. WM. MULLINS, *Esq., M.P., F.S.S., &c.**

HAVING for some years devoted all the time I could spare from other avocations to researches in voltaism and electro-magnetism, I frequently experienced considerable inconvenience from the impossibility of keeping up an equally powerful current of electricity for a period sufficiently long to answer my purposes; and in one particular instance, which I shall more especially refer to in a future paper, as connected with a very important discovery, the obstruction to the inquiries I was then making was so great, that I resolved, if possible, to conquer the difficulty, and conceived that notwithstanding the disappointments that had previously attended similar attempts, some means might still be discovered by which those consequences of chemical action on the metals employed in the galvanic circuit, and which Sir Humphry Davy and other distinguished philosophers had decided to be the chief cause of the decline of electric power, might be prevented, or, at all events, considerably diminished. I therefore commenced a series of experiments on this subject, in the course of which it struck me that a conducting substance interposed between the two metals would effectually protect *both* metals from the injurious effect of the gases and oxides formed while the battery was in action, while the electric current would find a free passage, and a surface of copper, or whatever other metal performed *its* functions, in the fittest state to receive it from the electrolyte. I had been previously in the habit of using membranous substances as conductors of voltaic electricity, in a course of experiments in which I had been engaged with the view of obtaining a new mode of developing voltaic power; and having found that thin membranes, when moistened in alkaline or acid solutions, af-

* Communicated by the Author. An abstract of Professor Daniell's paper on the Constant Voltaic Battery, recently constructed by him, will be found in our last volume, p. 421.