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On *Hyperodapedon*

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Notes

by metamorphic changes during the age of elevation which marked the close of the Palæozoic age in China, have hitherto resisted the action of the great solvent.

Other facts of interest in connexion with the geology of the districts treated of are, the absence of glacial action south of the Yangtse, and the large deposits of rich iron-ore, together with considerable quantities of coal, in the central provinces, while the careful study of the Tertiary and modern beds may probably at some future period throw light on the vexed question of the antiquity of the human race.

Discussion.

The President remarked that if the South of China had been dry land since so early a period, the fauna might have been expected to resemble that of the Siwalik Hills. Among the teeth was the molar of a very small horse, presenting some of the characters of *Hippotherium* or *Hipparion*, which might *possibly* be of Miocene date.

Prof. T. Rupert Jones alluded to the general parallelism of the axial folds of the strata with the coast-line, and to the similar strike of the gold-bearing rocks in the Gulf of Petchele, and mentioned that Cycadaceous remains occurred in the coal of some parts of Germany as in China.

Mr. W. Boyd Dawkins remarked that one of the equine molars was the largest of the class he had seen. He agreed with the President as to the smaller molar. He was unable, from the specimens, to determine whether they were Miocene or Pliocene. He mentioned the discovery in the laterite of India of a portion of a human femur of most remarkably slender make.

January 13, 1869.

William Groome, Esq., B.A., of St. John's College, Cambridge, was elected a Fellow; and Dr. J. F. Brandt, of St. Petersburg, Prof. A. E. Nordenskiöld, of Stockholm, and Prof. F. Zirkel, of Kiel, were elected Foreign Correspondents of the Society.

The following communications were read:—

1. *On* Hyperodapedon. By T. H. Huxley, F.R.S., Pres. Geol. Soc.

A little more than ten years ago, namely, on the 15th December 1858, Sir R. Murchison read a paper "On the Sandstones of Elgin" before this Society. It was followed by an essay of my own "On the *Stagonolepis Robertsonii*," an animal so named by Prof. Agassiz in his 'Poissons fossiles du Vieux Grès Rouge' from some impressions of its dermal covering which had been discovered in the Elgin sandstones. In the latter paper, and in notes added to both papers, before their publication in the middle of the following year, the fact that *Stagonolepis* was a reptile closely allied to the Mesozoic *Croco-*

dilia, though distinct from any known form of that age, was for the first time asserted, and, indeed, I may say, demonstrated, the remains placed in my hands enabling me to put the fact beyond doubt. At the same time I mentioned the existence in the same beds of "a Saurian reptile about 6 feet long, remarkable for the flattened or slightly concave articular surfaces of the centra of its vertebræ, and for its well-developed costal system and fore and hind limbs, but more particularly characterized by its numerous series of subcylindrical palatal teeth." I named this new reptile *Hyperodapedon Gordoni*, in honour of its discoverer, the Rev. Dr. Gordon, to whose exertions in the Elgin country geology owes so much: and I stated that "its marked affinity with certain Triassic reptiles, when taken together with the resemblance of *Stagonolepis* to Mesozoic *Crocodilia*, lead one to require the strongest stratigraphical proof before admitting the Palæozoic age of the beds in which it occurs."

Sir R. I. Murchison admitted that his belief in the Devonian age of the Elgin sandstones was "somewhat shaken" by the discovery of the nature and affinities of these reptilian remains.

In the ten years which have elapsed since the papers to which I have referred were read before the Society, the age of the reptiliferous sandstones of Elgin has been repeatedly discussed by some of the most eminent of English geologists, with the general result that while one half of the disputants produced excellent reasons for believing them to be of Mesozoic date, the other half adduced no less weighty arguments in favour of their Palæozoic age. And it is a curious circumstance that in this Geological Siege of Troy, Priam has been fighting the battle of the Greeks, and Nestor that of the Trojans,—Sir R. Murchison, whose general geological views would naturally incline him to assign a later date to these Elgin reptiles, having been the sturdiest champion of their Devonian age; while Sir Charles Lyell, who ought to rejoice if they could be made out Palæozoic, has as strongly fought for their belonging to the Trias. Without meaning to compare myself to Achilles, I may say that "under these circumstances" I thought it best to retire to my tents and take no part in the fray until my palæontological armoury should yield more efficient weapons. And as my excellent friend Dr. Gordon supplied me from time to time with new specimens, I lived in hope that one day or other I should be able to make an effective sally.

No such opportunity presented itself, however, until the year 1867, when a number of important facts came to light in singular coincidence, and, as I conceive, rendered the proper discussion of the question and the drawing of satisfactory conclusions somewhat easier than before.

I may premise that the original specimen of *Hyperodapedon* is in a very bad condition, the substance of the bones and teeth being extremely friable and decayed. It is nevertheless sufficiently clear that the roof of the mouth is provided with several parallel rows of teeth, that the edge of the ramus of the lower jaw is also beset with a series of close-set or even confluent teeth, and that the mandibular

teeth bite between the inner and outer series of the palato-maxillary teeth. The surfaces of the teeth, however, are not sufficiently preserved to enable one to make sure of the manner in which the teeth wear.

For a number of years I have been acquainted with two specimens from the quarry opened in a Triassic sandstone at Coton End, near Warwick—the one belonging to the Warwick Museum, and the other to the Rev. P. B. Brodie, F.G.S. Each of these is an elongated jaw-like bone, in which are set parallel rows of conical teeth; and I have often compared them with the palate of *Hyperodapedon*, but without being able to satisfy myself that I was entitled to draw any positive conclusions from their resemblance.

In the winter of 1866, however, the Rev. Dr. Gordon sent me several specimens, among which one (belonging to Mr. Grant, of Lossiemouth), though a very much mutilated fragment of a skull, presented part of the characteristic dentigerous bones of the palato-maxillary apparatus of *Hyperodapedon*; and my attention was, at once, forcibly drawn to the fact that the opposed faces of two of the rows of the teeth were worn down by attrition against other teeth. These two rows of teeth were placed on opposite sides of a deep longitudinal groove; and the planes of the worn faces converged to the bottom of this groove.

On looking at the original specimen, it became clear that this groove corresponded with the depression into which the oral edge of the mandible is received when the mouth is shut. The opposed faces of the palato-maxillary teeth had been worn flat by attrition against the opposite sides of the mandibular teeth, which work between them as a knife-blade shuts into its handle; and it followed that the dentary margin of the mandible must be worn to an edge adapted to fit into the groove. So far as I know, no other fossil reptile possesses any such peculiarities; and thus this interesting fragment presented me with new means of distinguishing the teeth and jaws of *Hyperodapedon* from those of other Reptilia.

Some time after I had become acquainted with Mr. Grant's new specimen, Mr. Lloyd, F.G.S., was good enough to call upon me for the purpose of showing me some specimens from the Coton-End quarry before mentioned, which had for many years been in the possession of his father, Dr. Lloyd, long well known for his attention to the geology of Warwickshire. Among these were two bones beset with teeth of the same character as those which I have already mentioned from the same locality, but far more perfect, and presenting rows of teeth not only quite like those of *Hyperodapedon* in form and arrangement, but worn in a precisely similar way; in fact, when Mr. Lloyd's specimens were placed side by side with Mr. Grant's, there was no resisting the conclusion that they proceeded from animals of one and the same genus, if not species.

I at once communicated these interesting facts to Sir Roderick Murchison, who refers to them in the following terms:—

"To such fossil evidence as this the field geologist must bow; and instead, therefore, of any longer connecting these reptiliferous

sandstones of Elgin and Ross with the Old Red Sandstones beneath them, I willingly adopt the view established by such fossil evidence, and consider that these overlying sandstones and limestones are of Upper Triassic age."

Shortly after these new lights upon the structure and stratigraphical position of *Hyperodapedon* had appeared, the able Director of the Geological Survey of India, Professor Oldham, who happened to be in England, drew my attention to some specimens obtained from Maledi, in Central India, and presented to this Society in 1860 by the Rev. Mr. Hislop. Among these were fragments of large jaws with teeth, which presented all the characters of *Hyperodapedon*; and during the past autumn I received from Dr. Oldham a considerable number of similar remains, associated with those of Labyrinthodonts and Crocodilian reptiles. The peculiar interest of this discovery arises not only from the sudden, enormous extension of the distributional area of *Hyperodapedon*, but still more from the circumstance that Dicynodonts have been found in the same Indian strata, and, thus, that we get a step nearer to the determination of the age of the remarkable reptiliferous formations of Southern Africa, the Triassic or Permian age of which was already highly probable.

The last fact which needs to be mentioned in this history of the gradually growing importance of the genus *Hyperodapedon* is the highly interesting and important collateral evidence as to its age obtained by Mr. Whitaker, who will presently give you an account of the precise position in the Trias of Devonshire in which a specimen of the jaw of *Hyperodapedon*, which he brought to me a few weeks ago, was obtained.

I now proceed to describe the most important remains of *Hyperodapedon* which have come into my hands; and I shall speak first of the specimen on which the genus was founded, which is the property of the Elgin Museum, and was sent to me in 1858.

The remains of this specimen are exhibited by the opposed faces of broken blocks of sandstone, some of which have been separated by splitting along the plane in which the fossil lay. On one of these blocks are the indications of seventeen vertebræ in a continuous series, though slightly disturbed from their normal position here and there. The bodies of all these vertebræ have about the same length, viz. 0·9 in. or 0·95 in. They are so much constricted in the middle as to be almost hourglass-shaped, and their terminal articular surfaces are slightly concave. In most of the vertebræ the neural arches and spines are shown indistinctly, or not at all; but the sixth in order from the anterior end of the series is tolerably complete, and exhibits a broad and not very high spine, the summit of which is somewhat narrower than the base. This passes into the arch of the vertebra, which exhibits well-developed articular processes. The total height of the vertebra, from the lower edge of the posterior articular surface to the summit of the spine, is 1·85 in., that of the posterior articular surface of the centrum being 0·7 in.

The fourteenth vertebra of the series, from its general character

and relations to the pelvis, is, without doubt, the principal sacral vertebra. The impression which it has left appears to me to have been formed by the outer face of the right sacral rib. Certainly not more than one of the three succeeding vertebræ, the two hindermost of which are represented by little more than casts of their neural canals and of the region thereabouts, can have been united with the principal sacral vertebra to form the sacrum.

On clearing away the friable remains of the original bone from the hard sandstone matrix, the latter presents casts of the external surface and of the neural canal of each vertebra, which, in some cases, are very perfect. These casts show no sign whatever of the deep pits which would correspond with well-developed transverse processes; but there is a depression at the anterior part of each body of a vertebra answering to what appears to have been a low tubercle for the attachment of a rib, as in existing lizards.

In correspondence with this structure of the vertebræ, the remains of a number of ribs, which have been laid bare by chiselling away portions of the matrix, show no trace of a division into capitulum and tuberculum at their vertebral ends. The longest of them is 4 inches in length. Like the rib of a *Monitor*, its vertebral end is somewhat expanded; and it is so curved as to be, at first, a little concave towards the dorsal aspect; in the rest of its extent it is convex in that direction.

I see no remains of true sternal ribs; but there are numerous faint transverse linear impressions of a system of dermal ossifications, which I conceive, answers to the so-called "abdominal ribs" of a Crocodile, or to the corresponding structures in *Sphenodon*. These, however, are better shown in another slab.

To the anterior extremity of the block of sandstone which contains these vertebræ (and which I shall call No. 1) fits another, which bears the anterior cervico-dorsal vertebræ and the skull. The latter is bent round so that its axis is nearly at right angles with that of the body.

None of these anterior cervico-dorsal vertebræ can be clearly made out; but they cannot have been numerous, and I doubt whether there were altogether more than twenty, or twenty-two, presacral vertebræ.

The skull had a length, when complete, of not less than 7 inches. It is about 5 inches broad posteriorly, but anteriorly narrows to a deflexed and comparatively slender snout, the diameter of which is not more than 1 inch. It is so disposed as to turn its ventral aspect to the eye. The left ramus of the lower jaw is in place, though much mutilated. The right ramus is broken away, and shows the oral surface of the palate and maxilla, with the obscure remains of several obtusely conical teeth.

On the left side, a good deal of the dentary edge of the left ramus of the mandible is preserved, and it is seen to be shut against the upper jaw, passing on the inner side of a series of mutilated teeth, which are fixed on the maxilla. The end of the snout presents a very remarkable structure. The anterior portion of the edge of each

maxilla curves upwards, so as to leave a deep notch between itself and the downwardly curved, beak-like anterior termination of the snout, which appears to be formed altogether by the præmaxillæ. Into this notch the surface of the matrix indicates that curved upward processes of the mandibular rami fitted. Whether these processes, and those of the præmaxillæ which projected between them over the mandibular symphysis, ended in teeth, or not, cannot be determined, as the extremities of the premaxillary processes are broken away, and the mandibular processes are represented only by impressions. But it is very likely that such was the case, if we may judge by the analogy of some existing lizards (such as *Uromastix spinipes*), which present a very similar arrangement of the extremities of the jaws. The two præmaxillæ, however, are confluent in this lizard, while they are distinct from one another in *Hyperodapedon*.

From the dentary margin the outer surface of each maxilla inclines rapidly outwards, so that, even making allowance for partial artificial depression, the measurement from the outer margin of one orbit to the other is nearly double that between the dentary margins of opposite sides. This conformation of the upper jaw also obtains, though to a less extent, in *Uromastix*.

The orbit was large; but its form cannot be accurately determined, almost the whole of the roof of the skull being absent. There is a cast of a strong supratemporal zygomatic arch, formed in part by a prolongation backward of the jugal, and in part by a forward extension of the squamosal, as in *Uromastix*. Clear indications of a strong quadrate bone and of a pterygoid are also visible; and the remains of a long slender left cornu of the hyoidean apparatus lies parallel with the left ramus of the mandible, on the ventral face of the skull. No remains of any infratemporal zygomatic arch, such as is found in *Chelonia*, *Crocodilia*, and *Aves*, are visible; but the existence of such a structure is very probable from the analogy of *Rhynchosaurus*.

The remains of two broad plates of bone, not less than $3\frac{1}{2}$ inches in length, with concavo-convex surfaces and a curved free edge, which lie near the anterior end of block No. 1, most likely represent the coracoids. A large impression of about the same length, which must have been formed by a bone which was thin at both edges, thin and expanded at one end, and thick, with an excavated terminal surface, at the other, lies near one of the coracoids; and I take it to have been made by a scapula. What I suppose to be a cast of the corresponding bone of the other side lies upon block No. 2; and there are sundry scattered imperfect impressions of limb-bones, indicating a fore leg of no great size. The right pubis and ischium have left very distinct impressions of their dorsal surfaces at the hinder end of block No. 1. In general form these bones resemble the corresponding bones in existing lizards; and the pubis has a great prepubic process, as in the latter. But the pubis and ischium of the same side seem to have united on the inner as well as on the outer side of the obturator foramen, which appears to have been proportionally much smaller than in existing Lacertilia.

The pubis and ischium occupy a space equal in length to four vertebræ, which is a proportion very similar to that which obtains in existing Lacertilia.

A distinct impression of the right femur is left almost in its natural position. It is a nearly straight and very strong bone, which is 4·7 in. long, or equal to more than five vertebræ in length. The femur has a similar proportional size in *Monitor* and *Iguana*. Impressions of the proximal ends of the tibia and fibula are visible, in such relation to the femur as shows them to have undergone very little disturbance.

No certain indication of the character of the feet is discernible.

The general arrangement of the teeth has been described. The downwardly convex dentigerous edge of the maxilla is 2·75 in. long, and appears to have carried about eighteen (or perhaps more) teeth, of a conical form and very closely set. The outer surface of the maxilla, from the dentigerous edge to the lower boundary of the orbit is fully an inch high, and is excavated and inclined outwards with a very peculiar curvature.

The dentigerous edges of the opposite maxillæ converge towards one another at an angle of about 45°, and then become parallel as the snout narrows to its termination.

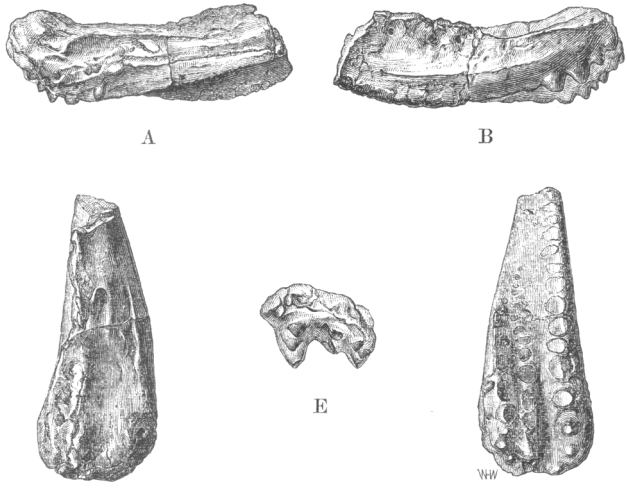
No suture can be distinguished upon the roof of the mouth, between the maxillæ and the palatine bones, though the boundary line between the two is probably indicated by the groove into which the dentigerous edge of the mandible bites. The roof of the palate is therefore formed by a broad plate of bone, which may be called palato-maxillary, as it is constituted by the conjoined maxillary and palatine. Anteriorly this plate has a width of not more than 0·35 in. internal to the groove, but it widens posteriorly to 0·7 in. Its inner edge is convex towards the middle line, roughly following the course of the dentigerous edge. For their anterior halves the two edges of the palato-maxillary bones seem to be separated by only a small interval; but posteriorly they diverge widely; whether the interspace was occupied by the pterygoids, or not, cannot be ascertained.

The palato-maxillary plate on the inner side of the groove bears three (or perhaps four) longitudinal series of conical teeth, the largest of which are about 0·1 in. in diameter at the base. The posterior edge of the palato-maxillary is abruptly truncated, smooth, rounded, and slightly concave backwards.

It is upon this part of the organization of *Hyperodapedon* that Dr. Lloyd's specimens throw such important light. One of them, which is smaller and more perfect than the other (fig. 1, A, B, C, D, E), exhibits nearly the whole of the characteristically convex dentigerous margin, and excavated and outwardly inclined outer face, of the palato-maxillary of *Hyperodapedon*. Its posterior margin is smooth and rounded below, exhibiting the natural termination of this part of the bone. The inner surface is also quite smooth, and could not have united suturally with any other bone. The anterior end of the bone is broken off transversely; but probably very little of it is lost. As it

is, it measures 1·5 in. in length; and the palatine surface has a width of 0·25 in. in front and 0·55 in. behind. The section of the bone is trihedral, the outer face of the trihedron being somewhat concave, the inner convex from above downwards; the anterior half of the upper edge is thin and broken; the posterior half is a comparatively broad, longitudinally grooved, narrow surface. Along the bottom of the groove lie three apertures, which are probably vascular foramina; and other such foramina lie on the inside and on the outside of the ridge into which the anterior half rises. One of the foramina on the inside is the commencement of a canal which traverses the base of the ridge longitudinally.

Fig. 1.—*Left palato-maxillary of* Hyperodapedon.



A. From the inside. B. From the outside. C. From above. D. From below. E. From behind.

The posterior half of the oral surface of the bone presents two faces, which are inclined towards one another at an obtuse angle; the wide valley which they include ends abruptly in a sharply cut narrow groove. On the outside of this groove lies a single row of fifteen teeth, anchylosed with the edge of the outer wall of the valley. The anterior eleven of these are worn down to a level with the bony substance of the jaw; the twelfth and thirteenth have their points ground away, while the fourteenth and fifteenth are entire and sharply pointed.

The inner wall of the valley presents two parallel series of teeth —one on the middle, and one on the extreme inner edge. Traces of fourteen or fifteen teeth can be discovered in each series. Those of the middle series are, all but the very hindmost, worn down to the

surface of the bone, while of the inner series the four hindmost teeth are but little affected by wear. The teeth of the outer series are larger than those of the inner, the base of the largest being 0·15 in. in diameter; the middle teeth in each series are the largest, the anterior and posterior diminishing in size.

The inner two series of teeth cannot be traced as far forward as the outer, the inner wall of the anterior half-inch of this valley being so thoroughly ground down that it is converted nearly into a plain. It is a curious circumstance that at the posterior part of the inner surface the apices of four teeth appear, as if they were about to protrude on this face. It is quite clear that this remarkable wearing down of the palato-maxillary teeth can only be explained by their attrition against the teeth of the mandible; and the sharpness of the groove in the posterior half of the palatal surface clearly shows that these mandibular teeth were themselves sharpened to a sort of knife-edge.

Dr. Lloyd's second specimen is a fragment of a larger palato-maxillary bone of the same (left) side. It is, however, smaller relatively to the original size of the bone, as some of the anterior portion is broken away, and the posterior edge, though nearly preserved, is somewhat imperfect. The transverse diameter of the nearly entire posterior end is 0·8 in.; so that this bone is about half as large again as the foregoing, and belonged to an animal probably not more than half as large as the Elgin specimen.

In this specimen the outer series of teeth is double posteriorly, two large conical teeth making their appearance on the outer side of the four which remain tolerably unworn. As before, there are two rows on the inner side of the groove; and anteriorly all the series of teeth are worn down to one flat surface with the bone which holds them.

Mr. Whitaker's specimen *, from Devonshire, is a right palato-maxillary bone of a *Hyperodapedon* of small size, probably less than that to which Dr. Lloyd's smaller specimen belonged. It is in an imperfect condition, but shows part of a single outer series of teeth, and of two inner series, both completely worn down. The apices of four or five teeth project in two rows upon the posterior half of the inner face of this specimen.

I propose to give a full account of the Indian specimens elsewhere. At present I merely wish to observe that, for the most part, they belong to animals of a larger size than the Elgin specimen, but that I have not yet discovered any grounds for regarding them as specifically distinct. In the series sent by Dr. Oldham, there is a fragment of a ramus of a mandible which shows the scissor-edge character of the dentary margin extremely well.

* I am indebted to my friends the Rev. P. B. Brodie and Mr. Kershaw for drawing my attention to some additional examples of the Warwickshire *Hyperodapedon*. Two of them are fragmentary palato-maxillary bones. The third has very much the appearance of two crushed palato-maxillary bones, with one ramus of the mandible of a small specimen; but I have not been able to work it out fully.

With respect to the affinities of *Hyperodapedon*, there can be no doubt that it is very closely allied to the genus *Rhynchosaurus*, established by Prof. Owen upon a fossil skeleton from the Trias of Shropshire. But *Rhynchosaurus* has shown no trace of teeth in either upper or under jaw, and seems to differ from *Hyperodapedon* as *Oudenodon* does from *Dicynodon*. There is a certain analogy with another Triassic genus, *Placodus*, in the dentigerous roof of the palate of *Hyperodapedon*; but too little is known of the rest of the organization of *Placodus* to test the value of this analogy.

I do not find grounds for assuming any special affinity between *Hyperodapedon* and *Telerpeton*; nor has *Hyperodapedon* anything to do with the Thecodonts, Crocodilian or otherwise, which abound in the Trias.

But it is a very remarkable circumstance that it is nearly allied to an anomalous lizard, *Sphenodon* (*Hatteria*), which still lives in New Zealand. Professor Owen first directed attention to some similarities in the construction of the skull between *Sphenodon* (under the name of *Rhynchocephalus*) and *Rhynchosaurus*. A short time since, however, the New-Zealand lizard furnished to Dr. Günther, F.R.S., the subject for an excellent memoir now published in the 'Philosophical Transactions,' in which the many anatomical peculiarities of this singular saurian were first indicated; and on perusing this memoir, I was at once struck with the resemblance in the arrangement and wear of the teeth, as described by Dr. Günther in *Sphenodon*, to that which I had become acquainted with in the fossil lizard.

I have since had the opportunity, by Dr. Günther's kindness, of inspecting his osteological and other preparations, and I have satisfied myself that *Sphenodon* is the nearest ally to *Hyperodapedon* of all recent or fossil reptilia, except *Rhynchosaurus*.

Both *Sphenodon* and *Hyperodapedon* have amphicœlous vertebræ (those of the ancient reptile being far less fish-like than those of the modern one, be it noted); both have beak-like præmaxillæ, not anchylosed together; both have the inferior zygoma complete; both have similarly formed lower jaws; in each, a single row of teeth in the mandible bites between two rows of teeth fixed to a plate which is formed by a union of the maxilla with the palatine bone—a structure which is quite anomalous among Lacertians; and, finally, in both, these teeth wear down to the bone of the jaw by the effect of masticatory attrition.

I now proceed to offer to the notice of the Society a few general considerations which arise out of the facts just detailed.

With respect to the habits of life of *Hyperodapedon*, I see no reason to doubt that it may have been a purely terrestrial animal—though it is a very hard matter, from the structure of a Lacertian, to say whether it is entirely terrestrial or largely aquatic. Consider, for example, how nearly the aquatic and terrestrial *Varani* resemble one another, and how slight is the difference between that species of *Amblyrhynchus* in the Galapagos Islands which cannot be driven

into the water, and that which takes to the sea habitually. All that can be said is that the Lacertilia are so predominantly terrestrial a group, that a member of the group is to be presumed terrestrial, or at any rate fluviatile, unless evidence appears to the contrary. True there is no evidence to the contrary in the case of *Hyperodapedon*; but, on the other hand, all that we know of its contemporaries and compatriots, *Stagonolepis* and *Telerpeton*, leads to the belief that they were terrestrial or semiaquatic. *Telerpeton*, I have little doubt, was altogether terrestrial. *Sphenodon*, the existing ally of *Hyperodapedon*, is a sluggish animal, which lives, in part, at any rate, on insects and small birds, and is said to frequent burrows in the sand near the sea-shore. The fact that no marine remains have ever been found in the deposits which contain *Hyperodapedon*-remains is negative evidence which leads in the same direction; and it is strongly confirmed by the association of Labyrinthodonts with *Hyperodapedon* in Warwickshire and in India,—Labyrinthodonts, like all other amphibia, being confined to the land and fresh water.

The question of the terrestrial habit of *Hyperodapedon* assumes a great importance when the wide distribution of the genus is taken into consideration. It has now been discovered in the North of Scotland, in the centre of England, and in Central India; and if it were, as I doubt not it was, a terrestrial or semiterrestrial animal, that alone indicates the existence of a very extended mass of dry land in the Northern hemisphere during the period in which it lived. And the proof of the existence of continental land in the Northern hemisphere acquires increased interest when we consider the evidence which shows what period this was.

The cardinal fact in that evidence is the occurrence of *Hyperodapedon* in the Coton-End Quarry in Warwickshire, as proved by Dr. Lloyd's specimen. It has never been doubted, I believe, that the Sandstone in which this quarry is excavated is of Triassic age. It has yielded Labyrinthodonts and Thecodont Saurians; and its stratigraphical position is such that the only question which can possibly arise is, whether it is Triassic or Permian.

As next in order of value, I take the discovery of *Hyperodapedon* in the Devonshire Sandstone, the determination of which as Trias rests, as Mr. Whitaker will inform you, upon independent grounds.

Thirdly comes the occurrence of the closely allied *Rhynchosaurus* in the Trias of Shropshire—a fact of subordinate value, but still by no means to be left out of sight.

These facts leave no possible doubt, as it seems to me, that *Hyperodapedon* is a reptile of Triassic age; but whether it is of exclusively Triassic age or not, and therefore whether it is, or is not, competent to serve as a mark of the Triassic age of the deposit in which it occurs, is quite another matter, and one respecting which it behoves us to speak very cautiously.

Crocodiles, with the same vertebral character as those which now live, and not known to be distinct even from the modern restricted genus *Crocodilus*, lived at the epoch of the Greensand, or, in other

words, are common to two of the great divisions of geological time. The like is true of the Teleostean fish *Beryx*. Moreover it has been seen that *Hyperodapedon* is nearly allied to the living lizard *Sphenodon*, —as nearly, I am inclined to think, as to its Triassic congener *Rhynchosaurus*. And if this extraordinary form has persisted with so little modification from the Trias till now, why may it not have inhabited the dry land of the Permian, of the Carboniferous, or of the Devonian Epoch?

In discussing the question of the age of the Elgin sandstones in years gone by, reflections of this nature led me always to admit the possibility that these problematical beds might be of Devonian age; for *Hyperodapedon*, *Stagonolepis*, and *Telerpeton*, though clearly allied to Triassic and Mesozoic genera, were distinct from them, and had no stronger affinities with Mesozoic Reptilia, than the *Proterosauria* have (which yet are Palæozoic and not Mesozoic), or than some of the Labyrinthodonts of the Coal (e. g. *Anthracosaurus*) have with those of the Trias.

Even now that *Hyperodapedon* is distinctly determined to be a Triassic genus, the possibility that it may hereafter be discovered in Permian, Carboniferous, or even older rocks, remains an open question in my mind. Considerations of this kind should have their just weight when we attempt to form a judgment respecting the reptiliferous strata of the Karoo in South Africa, and of Maledi and elsewhere in India.

In India, *Hyperodapedon* occurs associated with Labyrinthodonts, with Thecodont reptiles (some of which have Crocodilian characters), and with Dicynodonts.

In South Africa, *Hyperodapedon* has not yet been discovered; but Labyrinthodont and Thecodont Reptilia (some of them Crocodiliform) have been found, and, associated with them, abundant Dicynodonts.

In England and Scotland, *Hyperodapedon* is found with Labyrinthodonts and Thecodont Reptilia of such distinctly Crocodiliform type as *Stagonolepis*, but no *Dicynodon* has been found.

In Würtemberg, Labyrinthodonts and Thecodont Reptilia, some of them, like *Belodon*, eminently Crocodilian, are associated together, probably with Dinosauria; but neither *Hyperodapedon* nor *Dicynodon* have yet been discovered.

All these four faunæ are connected by reptilian genera, which are respectively common to two of them: thus the British and the Indian by *Hyperodapedon*; the Indian and the African, by *Dicynodon*; the British and the German by *Labyrinthodon* (which according to Von Meyer occurs in Germany). The Labyrinthodonts and Crocodiliform reptiles are common to all four.

As the age of the beds in question is determined stratigraphically in Britain and in Germany to be Triassic, it may seem over-refinement to hesitate in declaring the African and Indian formations to belong to the same period; but I confess that the arguments I have mentioned lead me greatly to prefer some more general term, which should indicate a wider chronological range for the duration of the terrestrial fauna in question. The term *Poikilitic*, originally used

by Conybeare to designate the Newer Red Sandstones of this country, seems to me to be very fit for this purpose; and in speaking of the Poikilitic period, I should like to make its earlier and later boundaries as hazy as possible, and to apply it exclusively to terrestrial conditions and to land and freshwater faunæ, without prejudice to the limits in time of the marine conditions known as Permian and Triassic.

It does not appear to me that there is any necessary relation between the fauna of a given land and that of the seas of its shores. The land faunæ of Britain and of Japan are wonderfully similar; their marine faunæ are in many ways different. Identical marine shells are collected on the Mozambique coast and in the easternmost islands of the Pacific; while the faunæ of the lands which lie within the same range of longitude are extraordinarily different. What now happens geographically to provinces in space, is good evidence as to what, in former times, may have happened to provinces in time; and an essentially identical land-fauna may have been contemporary with several successive marine faunæ.

At present, our knowledge of the terrestrial faunæ of past epochs is so slight, that no practical difficulty arises from using, as we do, sea-reckoning for land time; but I think it highly probable that, sooner or later, the inhabitants of the land will be found to have a history of their own,—mixed up with that of the sea, indeed, but independent of it, in some such relation as the histories of England and that of France.

If the terrestrial faunæ which I thus propose to term *Poikilitic*, were, in the historical sense of the word, contemporaneous, it would appear to be highly probable that, at their epoch, as at the present day, animals were distributed in distinct geographical provinces. It cannot well be a matter of accident that, with such uniformity in general *facies*, there is such diversity in detail between the four faunæ I have mentioned. And it is very interesting to remark that, just as at the present day, the Poikilitic fauna of India had distinct and independent relations, on the one hand, with that of Europe, and on the other with that of South Africa.

But I am disposed to think that there is a closer connexion than that of mere analogy between the geographical distribution of terrestrial animals in the Triassic epoch and that which obtains at the present day.

In the famous sandstones of the Connecticut valley, in North America, neither bones nor teeth have yet been discovered; but the foot-tracks show that either ornithoid Sauria, or true birds, or most probably both, existed in the Poikilitic period. Some of these bird-like creatures, such as the *Brontozoum*, were of gigantic size. They were associated with true reptiles, some of which, very probably, resembled the *Hyperodapedon* and *Rhynchosaurus* of western Europe.

With these facts before one's mind, how striking do the characters of the existing fauna of New Zealand appear! Its one characteristic reptile is *Sphenodon*, so extraordinarily similar to *Hyperodapedon*;

its most characteristic birds are the giant *Dinornithidæ*, some of which were competent to keep stride with the *Brontozoum* itself.

What if this present New Zealand fauna, so remarkable and so isolated from all other faunæ, should be a remnant, as it were, of the life of the Poikilitic period which has lingered on isolated, and therefore undisturbed, down to the present day?

I am quite aware that a host of difficulties may be opposed to this suggestion; but these all seem to me to be rather of the nature of questions which cannot be answered for want of information, than of objections formidable in themselves. For example, mammals existed in the Poikilitic epoch. Why did none of these inhabit the New-Zealand area and survive to the present day? Again, how comes it that the solitary amphibian of New Zealand is a Frog allied to those of South America, and not a Labyrinthodont? And why are the freshwater fishes also allied to, and, in one case, specifically identical with those of South America*, instead of resembling Triassic Ganoids?

I cannot give a direct answer to these questions, but I can show that analogous difficulties exist in cases where there can be no sort of doubt as to the origin of a fauna. Thus there can be no doubt that the fauna of Ireland is derived from the same source as that of Europe; but just as New Zealand is devoid of the class Mammalia, so is, or was, Ireland devoid of the class Reptilia; again, there is no indigenous British Ganoid or Siluroid freshwater fish, though both occur in the rivers of Central and Eastern Europe.

May it not be possible that causes similar to those which have shut out whole groups of Vertebrata of the European fauna of the present epoch from the British region, operated upon New Zealand in the Poikilitic period and caused its fauna to represent only a fraction of that of neighbouring lands? Or may it not be possible that causes such as those which determined the extinction of the indigenous horse, *Macrauchenia*, *Toxodon*, *Glyptodon*, &c. of South America, while they left multitudes of other genera alive, have similarly weeded down the fauna of New Zealand, and that investigations in the caves and superficial deposits of that country will yield forms which now no longer exist there?

I mention these possibilities simply for the purpose of showing how much greater value attaches to the positive similarities between the New-Zealand Fauna and that of the Trias than to their negative differences.

Finally, I may remark upon the complete modification of former ideas respecting the supposed poverty of life during the Poikilitic epoch which has been effected by the discoveries of late years.

It is now clear that all the five classes of the Vertebrata, viz. Mammalia, Aves, Reptilia, Amphibia, and Pisces, were represented at this epoch. The mammals were apparently Marsupials, not Monotremes. Of the birds nothing is known. Of reptiles, we have Dinosauria, Crocodilia, Dicynodonts, Lacertilia of several forms, Ple-

* I state these remarkable distributional facts on the high authority of Dr. Günther, F.R.S.

siosauria, and perhaps Ichthyosauria; of Amphibia, a great number of Labyrinthodonts, some of which were of enormous size; of fishes, Ganoids and Elasmobranchs.

So long as mammals and birds were known to occur no further back than the older Tertiaries, or the middle Mesozoic rocks, it might be legitimate to imagine that they came into existence somewhere between that time and the end of the Palæozoic series. But now that both are to be traced back to the Trias, that it is known that the Crocodilian and Lacertian types of reptiles were then in existence, and that the Amphibia were elaborately represented, I confess it is as possible for me to believe in the direct creation of each separate form as to adopt the supposition that mammals, birds, and reptiles had no existence before the Triassic epoch. Conceive that Australia was peopled by kangaroos and emus springing up ready-made from her soil, and you will have performed a feat of imagination not greater than that requisite for the supposition that the marsupials and great birds of the Trias had no Palæozoic ancestors belonging to the same classes as themselves. The course of the world's history before the Trias must have been strangely different from that which it has taken since, if some of us do not live to see the fossil remains of a Silurian mammal.

Discussion, see p. 157.

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2. *On the* Succession *of* Beds *in the* "New Red" *on the* South Coast *of* Devon, *and on the* Locality *of a* New Specimen *of* Hyperodapedon. By William Whitaker, B.A. (Lond.), F.G.S., of the Geological Survey of England.

The following account of the successive beds that are shown in the "New Red" cliffs of South Devon, is from notes taken during a holiday-walk along that coast last September, and it has been drawn up at the request of Prof. Huxley, in order to mark the stratigraphical place of the *Hyperodapedon* jaw from near Budleigh Salterton.

I believe that the only paper which treats of the order of these beds is a full report of two lectures by Mr. Pengelly, F.R.S.* To this I refer the reader for a more detailed account of the composition of the various "red rocks."

Owing to the dip, lower and lower beds rise to the surface southwestward, so that an almost continuous section is given.

The occurrence of the uppermost part of the "New Red" near the eastern boundary of the county, and its passage upwards into the Lias, have been noticed by Sir H. De la Beche †, and more fully by Mr. Pengelly ‡; but the cliffs here are so much hidden by fallen

* Trans. Plymouth Inst. for 1862–63 and for 1864–65.

† Trans. Geol. Soc. Ser. 2, vol. i. p. 42, and Plate 8 (1822). Report on the Geology of Cornwall, Devon &c. p. 209 (1839).

‡ Trans. Plymouth Inst. for 1864–65, pp. 33–36.