

its most characteristic peculiarities, it appears probable that the chemical reactions in protoplasm are largely controlled by variations in the electrical potential-differences present at the various protoplasmic phase-boundaries (the surfaces of membranes, fibrils, etc.). At present our knowledge of chemical processes occurring under electrical control is almost entirely confined to those observed at the surfaces of metallic electrodes in contact with electrolyte solutions. These are the well-known phenomena of electrolysis. Knowledge of such processes should be extended to include the case of electrolysis at other interfaces, *e. g.*, between an oil phase and a water phase. The technical difficulty here appears to be largely one of conducting the current through the non-aqueous phase. But since many of the chemical reactions in protoplasm are demonstrably under electrical control, it is clear that metallic surfaces (*i. e.*, metallic electrodes) are not necessary to the production of chemical effects by the electric current. Apparently in the living cell surfaces of other composition play the same part. There seems to be here a field of investigation which should throw much light upon the conditions of the chemical processes in protoplasm. The phenomena of polar stimulation, polar disintegration and similar effects in physiology are an obvious counterpart of the polar differences between the chemical effects of anode and cathode in electrolysis. Undoubtedly the same fundamental basis exists for the polarity in the chemical effects of the electric current in the living and in the non-living systems. The effects produced by passing currents through appropriately constituted emulsion-systems containing readily alterable (*e. g.*, oxidizable) chemical compounds might well be investigated to advantage in relation to this problem. Closely related also would be a study of the surface-films formed at the interfaces between pairs of fluids, or between fluids and solids, and the effects of electrical and other conditions upon such films.

Progress in these and related departments of physical research would undoubtedly be of great service to general physiology at the

present stage of its development. Many fundamental physiological processes—growth, cell-division, muscular contraction, response to stimulation, transmission of stimuli, chemical control of metabolism, etc.—must remain imperfectly intelligible without the extension of exact knowledge in these fields. The possibilities of the control of vital processes, including the control of diseased conditions, would certainly be greatly enlarged with a more fully developed general physiology. The problems suggested above have many aspects of purely physical and chemical interest, apart from their physiological bearing; and it is to be hoped that properly equipped investigators may be found to engage in their study.

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THE LONGNECK SAUROPOD BAROSAURUS¹

IN 1889 Professor O. C. Marsh secured from the shales overlying the sandstones following the marine Jura, near Piedmont on the eastern "Rim" of the Black Hills, various fragmentary caudals of a huge sauropod. In these he recognized a new type which he called *Barosaurus lentus*. He had been kindly advised of the occurrence, and was accompanied by the noted collector J. B. Hatcher, but attempted no adequate excavation.

Nine years later, in the midwinter of 1898, after a friendly letter from Professor Marsh, I visited him at New Haven and discussed the subject of field work in the west for the succeeding summer. Knowing that after Hatcher left Yale several years earlier the field work on the Dinosauria had suffered, I

¹ 1890. O. C. Marsh, *Barosaurus lentus* gen. et spec. nov. in "Description of New Dinosaurian Reptiles," *Amer. Jour. Sci.*, January, page 86, Figs. 1 and 2. 1919. R. S. Lull, "The Sauropod Dinosaur *Barosaurus* Marsh—Redescription of the Type Specimens in the Peabody Museum, Yale University," *Memoirs of the Connecticut Academy of Arts and Sciences*, Vol. VI., pp. 1-42, with figures in text and 7 plates.

wished to begin with that group, through general interest in the reptilia. But two other subjects also claimed attention—the fossil cycads and the great turtles of the Pierre. The cycads I had wished to hunt for when in the Black Hills; and the studies begun with the discovery of the huge *Archelon*, the most remarkable of sea-turtles, urgently needed continuation. However, as to which subjects should take the precedence Professor Marsh was close to obdurate—they should be within my interest. This I recall pleasantly; for mayhap vertebrate paleontologists are a bit prone to use the word “direct” with a sort of obviousness. It may occur on labels in letters of inconsistent size, or in descriptions. But this was not Marsh, as I can testify. He advised with others, however meager their experience, was anxious for their best word, and valued the mental sanction of those he worked with. Only may this be called direction in the sense of singling out the roadway along which to make history. And in this sense, when it came to the fossil-bearing horizons of the west, was there ever another such a man as Marsh? He said, as I left for the field—“The Black Hills are a diamond edition of geology, prepared especially for the use of geologists by the Almighty.”

Accordingly, in the latter part of August, 1898, I began the excavation for *Barosaurus*. This I carried out alone. The quarry was extended to a sixty-foot front, and ran some thirty feet back to a depth of ten feet. The first material secured was fragmentary and seemed to run out following a group of good caudals. Then a well-conserved portion of a proximal caudal, probably No. 1 was uncovered; but on interrupting the work for further prospecting for the cycads and dinosaurs, the centrum was found cut off by an ugly shear. Nearly decided that the lead had come to an end, on working down to a two-foot lower level, various dorsals, a few chevrons, rib fragments, and a sternal plate, promised a rather featureless aggregate. Much checking with extreme lightness of the vertebral structure made it necessary to hold

all parts in place as uncovered. This slow task lasted into the late fall, when cold and dust storms made excavation difficult.

Finally, in the course of working forward, there came four cervicals running up to one with a centrum three feet long, at once recognized as unparalleled in the Dinosauria; though much more robust types as long are now known. It then appeared that the main group of skeletal elements, although much displaced, or only partly conserved, represented a single individual; but unluckily the long cervicals led out to a gullied surface. All possibility of further recovery was at an end. Yet the result seemed a real triumph, over which Marsh was quite elated; he held in hand novel Dinosaurian material new from the field.

And now, after twenty-two years Professor Lull, of Yale, has described this unique type in the excellent memoir of the Connecticut Academy cited. Since its discovery, Riggs has named a very striking sauropodan from Colorado, *Brachiosaurus altithorax*, from the huge humeri exceeding in size the femora; while the related *Gigantosaurus* was later found in the Tendaguru of East Africa. These are quite the largest of Dinosaurs. Also, *Diplodocus* has been reintegrated with signal success at the Carnegie Museum of Pittsburgh.

The *Barosaurus* has, as Marsh thought, some resemblance to *Diplodocus*. In that genus length of neck, dorsal shortness, and great caudal length, are correlated with lightness of vertebral structure. In *Barosaurus* the vertebral type is very similar, with shortness of the dorsum. But Professor Lull finds a strong presumption that the humerus exceeded the femur in length, as in the American and African high-shouldered sauropods; while the length of neck is extreme, with a lesser caudal length.

Fortunately *Barosaurus* (type) includes in good condition at least the proximal half of the pubis. The pubis is one of the most variable and characteristic skeletal elements throughout the Dinosauria, and Lull finds a primary resemblance to *Diplodocus* which may

possibly be contested. It is true that there is in both forms a long shaft constriction. But in *Barosaurus* the ischiatic contact is not short, but long or rather deep, and concave as in *Apatosaurus*. The type is in this feature composite. In fact if a form uniting features of the greater sauropods, including the *Camarasaurus*, were sought, so far as public features go, *Barosaurus* might well be named.

Regarding a proximal femur fragment which is found to far exceed the proportions in *Diplodocus*, I may say that in no case is the femoral size absolutely determinate as large. The group of fragments from a Piedmont village "rock pile" or "fossil heap" purported to come from the *Barosaurus* quarry site. But only seven miles northerly there was an exposure of a fast disappearing Dinosaur bone bed several acres in extent. Being all outside the frost line, the material present in variety was much checked and broken. So fragments of limb bones could have been taken from this point to the "rock pile" at Piedmont, mainly, if not exclusively from the real *Barosaurus* outcrop. Or again, if the record fails, it is to be recalled that a second (though actually smaller) dinosaurian was recognized by Marsh in the material from the outer edge of the quarry, as confirmed by Lull. The point is that if a second form could so occur on the erosion or quarry front, then there might also be a third. A waterway, stream, or trend of some kind is indicated.

It is worthy of addition that in the *Barosaurus* quarry well inside the frost line, there were various fragments of charred or carbonized wood passing into silicified structure. Such material from the Morrison has not been studied. Also, various pebbles of a singular smoothness were noted at only one point close to the main group of dorsals. As the specimen was incomplete the reasonable explanation that these were stomach stones, or as later called, dinosaurian gastroliths, did not then occur to me, their true character being first recognized in examples from the Big Horn mountains.

Obviously *Barosaurus lentus* is a remarkable dinosaur from several points of view. It comes from far to the north and east of the Wyoming localities, and shows the great extent of the Como beds, as Marsh called them. The parallel with the African types adds great interest to *Barosaurus*. As a specimen it promised little of determinate value after two months quarry work, and then suddenly turned out to be, "except for the lack of limbs, one of the finest of all Yale specimens." The type remains somewhat isolated because collecting along the inner edge of the Black Hills "Rim," though never hopeless, is always much limited by the long talus slopes hiding the Morrison. This formation encloses the Hills and the Bear Lodge horseshoe-like, with the open heel on the southeast from north of Buffalo Gap to near Minnekahta. On the west side of the Hills the maximum thickness of 200 feet is reached. There, as further west in the Big Horn Rim and in the Freeze Outs, is found the association of the smaller silicified cycads with the sauropod Dinosaurs. And both in the Morrison, and in the overlying Lakota, from the lowermost strata of which comes the fine cycadeoid *Nilssonia nigracollensis*, a long contemporary cycadophytan and dicotyl record of the Comanchean is yet to be brought to light. Reconnaissance in this important field is but begun.

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PROFESSOR of physical geology in the Sheffield Scientific School of Yale University for twenty-one years, after rapid promotion from the position of instructor in geology and lithology, to which he was appointed in 1892; Professor Pirsson also occupied a position of commanding importance in the administrative work of the Scientific School, as member of the governing board, and as assistant to the director, Professor Chittenden, in matters of discipline and general policy. An assistant in analytical chemistry for six years after graduation from the Scientific School, he