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THE DEINOCERATA OF WYOMING

Dinocerata, a Monograph of an Extinct Order of Gigantic Mammals. By O. C. Marsh. Monographs of the U.S. Geological Survey. Vol. X. (1884.)

ON the high plateau that lies to the west of the Rocky Mountains, along the southern borders of Wyoming Territory, the traveller who is moving westwards begins to enter upon a peculiar scenery. Bare, treeless wastes of naked stone, crumbling into sand and dust, arise here and there into terraced ledges and strange tower-like prominences, and sink into hollows where the water gathers in salt or bitter pools. Under the cloudless sky, and in the dry clear atmosphere, the extraordinary colouring of these landscapes forms, perhaps, their weirdest feature. Bars of deep red alternate with strips of orange, now deepening into sombre browns, now blazing out again into flaming vermilion, with belts of lilac, buff, pale green, and white. And everywhere the colours run in almost horizontal bands, the same band being continuous and traceable from hill to hill, and tower to tower, across hollow and river-gorge for mile after mile through this rocky desert. These parallel strips of colour mark the nearly horizontal stratification of the rocks that cover all this wide plateau country. They are the tints characteristic of an enormous accumulation of sedimentary rocks that mark the site of a vast Eocene lake or succession of lakes on what is now nearly the crest of the continent. These lacustrine sediments, in all somewhere about two miles in vertical thickness, were doubtless laid down during a slow subsidence of the lacustrine area, when the subterranean movements were in progress that finally gave the mountain-ranges and plateaux their present forms and altitudes. They represent a vastly protracted period of quiet sedimentation, in the immediate proximity of an extensive land-surface plentifully clothed with a tropical vegetation, and abounding in varied forms of animal life. They consequently offer to the geologist peculiar facilities for investigating the evolution of a fauna apparently exposed to the minimum of interference from changes in its environment.

It is now about fifteen years since the wonders sealed up within the sediments of these vanished lakes first began to be known. The wandering Indian, indeed, had long been familiar with the skulls and skeletons which, by the decay of the inclosing rock, looked out upon him from the side of *butte* and *cañon*. But he revered them as the bones of his ancestors, and left them untouched, to be disinterred by the ceaseless working of wind and rain. The earliest trappers, squatters, and prospectors brought back news of marvellous monsters grinning from the ledges of rock beneath which they camped. At last these tales attracted the notice of some of the enthusiastic naturalists in the eastern States. Prof. Leidy, of Philadelphia, obtained a number of bones from which he was able to bring to light an entirely novel, and now wholly extinct creature, to which he gave the name of *Uintatherium*. Prof. E. W. Cope likewise described some forms disinterred by him in the same region. But the earliest and most successful investigator of these remains is Prof. O. C. Marsh, who, as far back as 1870, began the search in the Green River basin, and who, after many years of most laborious research, both among the western deserts and in his wonderful collection at Yale College, has at last been able to publish this splendid monograph on the Deinocerata. No trouble or expense has been spared to obtain material for the study of these strange extinct creatures. One expedition after another has been despatched to the West, and many tons of bones have been deposited at Yale, where it is believed there are now represented more than two hundred individuals of the Deinocerata alone. Some of these remains are admirably preserved; indeed, had the animals been still living, the materials for a knowledge of their osteology could hardly have been more perfect than it is.

The Deinocerata form an order established by Prof. Marsh to include some peculiar and well-marked forms found in the lacustrine deposits of the Green River basin—a tributary of the Colorado River of the West. This order belongs to the Ungulates, some of the characters allying it with the Artiodactyls (*Paraxonia*), others with the Perissodactyls (*Mesaxonia*); while in others, again, it is linked with the Proboscidians. The points of resemblance, however, are usually, in the author's opinion, such general characters as seem to point backward to some ancestral ungulate, rather than to any near affinity with existing forms of these groups. The Deinocerata include three genera which occupy three successive stratigraphical horizons. The oldest, Uintatherium, found in the lower strata of the Eocene lake, appears to be the most primitive type; the youngest, *Tinoceras*, found at the highest level, is the most specialised; *Dinoceras* being an intermediate form. The number of species belonging to the order has not been satisfactorily determined, but about thirty forms more or less distinct have been recognised.

Comparing *Dinoceras* with the large living Ungulates, Prof. Marsh points out that in size and proportions it was intermediate between the elephant and rhinoceros, but had also features akin to those of the hippopotamus, while in its stature and movements it probably resembled the elephant as much as any existing animal. It presented certain striking peculiarities which at once marked it off from any form now familiar to us. The skull in particular wore an altogether extraordinary aspect. It was long and narrow, and on its top it supported three separate transverse pairs of high osseous protuberances or horn-cores, which may have been covered with bosses of thick skin, and were no doubt powerful offensive weapons. The canine teeth were enormously developed in the male, forming short, trenchant, decurved tusks, which were protected by a dependent process on the lower jaw. The nasal bones were so elongated as to form nearly half the length of the entire skull, projecting forward and overhanging the premaxillaries. There was probably no proboscis, for the neck was long enough to allow the head to reach the ground without it, but there is some evidence of a thick flexible lip, perhaps like that of the rhinoceros. The brain was proportionately smaller than in any other known mammal, recent or fossil, and even less than in some reptiles. In one species at least it was so diminutive that it apparently could have been drawn through the neural canal of all the pre-sacral

vertebræ, certainly through the cervicals and lumbars. The limbs were massive and heavy, the bones, like those of the rest of the skeleton, being nearly or quite solid. The fore-foot was larger than the hind-foot, its component bones being comparatively short and massive, with five well-developed digits, as in Proboscidians, but the carpal bones interlocked with the metacarpals as in Perissodactyls. The feet, as in the modern elephant, were plantigrade, and were doubtless covered below with a thick pad.

We can picture these dull, heavy, slow-moving creatures haunting the forests and palm-jungles around the margin of a great lake. Into the quiet depths of that lake their carcases from time to time found their way, swept down perhaps by river-floods. Among their contemporaries were other forms whose remains have also been more or less abundantly preserved in the same deposits. Of these, two genera next in size to the Dinocerata were Perissodactyl ungulates somewhat larger than a tapir (*Palæosyops* and *Limnohyus*). Another interesting form is *Orohippus*—a four-toed ancestor of the living horse, while additional varieties of the ungulate type were related, though distantly, to the tapir and rhinoceros (*Colonoceras*, *Helaletes*, *Hyrachyus*). Two remarkable genera (*Tillotherium*, *Stylinodon*), nearly as large as a tapir, possessed characters resembling those of the ungulates, carnivores, and rodents, and have been embraced by the author in a new order called by him *Tillodontia*. Among the carnivores there was one (*Limnofelis*) nearly as large as a lion; and another hardly less in size (*Oreocyon*), while *Dromocyon* was somewhat smaller and *Limnocyon* about as large as a fox. There were likewise lemurs having some affinities with South American marmosets; also representatives of the Marsupials, Insectivora, Chiroptera, and Rodentia, but no true Quadrumana or Edentates. Reptiles abounded, especially crocodiles, turtles, lizards, and serpents, while fishes of many kinds swam in the lake.

The structure and history of the Deinocerata with their place and affinities in the animal kingdom are fully discussed in this important monograph. Like his previous work on toothed birds in the same series of memoirs, Prof. Marsh's present volume is an admirably executed and exhaustive research. Every bone is carefully worked out and drawn. Every available fragment of evidence is patiently collected, compared, and tabulated. Whatever may be disputable regarding the conclusions drawn, there can be no variety of opinion as to the actual data. No fewer than fifty-six lithographic plates, and nearly 200 woodcuts depict with singular fidelity every part of the skeleton of the Deinocerata as at present known.

But Prof. Marsh is much more than a comparative anatomist. It is not enough for him to describe the bones he has unearthed, and to point out their analogies in the living world. He is instinctively an evolutionist, and every extinct animal seems to propound to him the problem of its ancestry and its descendants. One of the most suggestive chapters in his present memoir is devoted to the genealogy of ungulate animals, and the place of the Deinocerata among them. He believes that from some primitive form, of generalised type, probably small in size, resembling generally an insectivore, and going back at least as far as Permian time, all the mammalian tribes have descended. Such a genealogical mammal, belonging to Prof. Huxley's group of *Hypotheria*, would possess all the general characters of the subsequently developed mammalian orders. But special characters, acquired in adaptation to conditions of environment, would be developed in the course of time, and would lead to the establishment of different modified types. The general characters would thus alone be a safe guide in tracing a community of ancestry, while those of a special kind need not necessarily indicate affinity, but may have independently arisen from the influence of the same surroundings in groups already quite distinct from each other. In the Cretaceous system, a well-marked group of mammals is found which is represented now by the living Hyrax, along what appears to have been the main stem of ungulate descent. From this stem, after the remarkable waning of reptilian life at the close of the Mesozoic ages, there diverged, in Cretaceous times, a branch which terminated in *Coryphodon*—a tapir-like form which, both in America and in Europe, probably quite equalled if it did not surpass in size and power any of the representatives of the fading reptilian types of an older creation. Another branch which may have been given off about the same time reached its full development in the Deinocerata, which were certainly the monarchs of the region where they lived. But nothing is more striking in the history of these and the other colossal mammals than the rapidity with which they appear and disappear from the scene. *Dinoceras* and its allies, so far as the evidence yet goes, appear to have been restricted to the middle part of the Eocene period. Their remains are not found in the earlier deposits of that period, and cease to occur before we reach the upper parts of the series. The cause of this speedy extinction is to be sought, according to Prof. Marsh, in the small brain of the animals, their highly specialised characters, and huge bulk, whereby they were unfitted for adapting themselves with sufficient rapidity to new conditions; and a change of surroundings brought about their extinction. But this is a point on which the geologist may not unnaturally claim to be heard when he demands some evidence of such change of surroundings. Had the supposed geological vicissitudes been sufficiently serious to cause the extinction of a whole tribe or sub-order of large mammals, they might have been expected to have left some palpable evidence of their passage in a corresponding change in the nature of the deposits accumulated in the lakes. But there is certainly nothing in the nature or succession of these deposits to suggest that any important modifications of topography or climate took place during the time when they were being deposited. On the contrary, they seem to point to protracted uniformity in the conditions of sedimentation. They afford no indication whatever that the successive appearance of *Coryphodon*, *Dinoceras*, and *Diplacodon* was accompanied, far less was determined by, any essential change of physical conditions. That such change actually took place is of course quite conceivable, but when it is demanded as an essential factor in mammalian evolution, some admissible proof may very fairly be demanded.

Like Prof. Marsh's previous memoir on "Odontornithes," the present volume may be regarded as a model monograph. It is complete without being overloaded,

exhaustive and yet lucid and interesting from beginning to end. After reading it one feels that the Deinocerata are no longer extinct, vanished forms, but familiar acquaintances which one could not fail to recognise anywhere. Every part of their structure is methodically presented to view, and restorations are given showing the relations of the parts to each other and what is the author's conception of the general form of the animals. It has hardly ever been possible in the Old World to reconstruct the mammalia of so early a period from such ample materials as are now amassed at Yale College. Hence the restorations attempted have often been little more than more or less probable conjectures which might be conformed but were more usually corrected or even effaced by the progress of discovery. So full, however, is the evidence for Prof. Marsh's restorations, that there remains very little room for future emendation. He is still engaged in continuing these remarkable memoirs on the ancient life of the North American continent. A third monograph on the *Sauropoda* is approaching completion, and a fourth, on the *Stegosauria*, is far advanced. These large and profusely illustrated works are issued as part of the work of the United States Geological Survey. They reflect the highest honour on their indefatigable author, and on the Survey which undertakes their publication.

ARCH. GEIKIE

REMSEN'S "ORGANIC CHEMISTRY"

An Introduction to the Study of the Compounds of Carbon; or, Organic Chemistry. By Ira Remsen, Professor of Chemistry in the Johns Hopkins University. Pp. x., 364. (Boston: Ginn, Heath, and Co., 1885.)

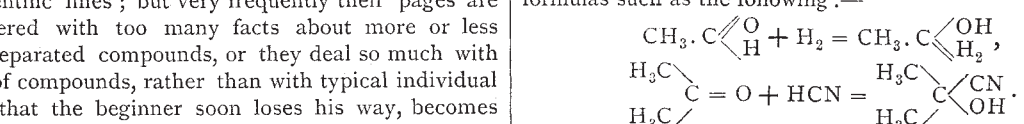
THIS is chemistry. Of how few books professing to be books on chemistry can it be said that they teach us anything of the science. The student who begins the study of the carbon compounds has to suffer many things from the text-books. Some of them present him with dry bones in the shape of isolated facts and bold assertions regarding structural formulæ and the linking of atoms. Others lead him into speculations which he is unprepared to follow; he makes little flights into these and comes back fancying he is a chemist. Other books (there are not many of them) proceed on the true scientific lines; but very frequently their pages are encumbered with too many facts about more or less widely separated compounds, or they deal so much with groups of compounds, rather than with typical individual bodies, that the beginner soon loses his way, becomes perplexed, and is ready to abandon the pursuit.

Prof. Remsen has shown us a more excellent way than any of these. He leads the learner by degrees through the early difficulties; he places before him distinct and detailed accounts of a few typical compounds; he shows him how these compounds are mutually related; and then he takes him back to the beginning again and teaches him how each compound he has learned to know represents a group, and how, when he knows the properties of one member of the group he also knows much about all the members.

At the outset Prof. Remsen makes a few wise and pregnant remarks on the meaning of structural formulæ. These "enable the chemist who *understands* the language in which they are written to see relations which might easily escape his attention without their aid. In order to *understand* them, however, the student must have a knowledge of the reactions upon which they are based; and he is warned not to accept any chemical formula unless he can see the reasons for accepting it." The whole book is a practical sermon on this text.

In no other elementary book in the English language will the student find so many admirably chosen examples of the formation of structural formulæ. The important facts are noted; then the inference is drawn; then the hypothesis is ventured upon; analogous facts are recalled; the hypothesis is strengthened or weakened; suggestions are made; experiments are conducted; and all is finally summarised in the formula. But the book is more than a selection of examples showing how structural formulæ ought to be gained. It is a systematic although elementary treatise on organic chemistry. The student is first taught about the two paraffins, methane and ethane; then he learns how the halogen derivatives of these are prepared, and what relations they bear to the parent hydrocarbons. By this time he has had his first taste of isomerism. Then he proceeds to the oxygen derivatives of methane and ethane; he learns what an alcohol is; he becomes acquainted with ether, aldehyde, formic and acetic acids, some ethereal salts, and acetone. This method of studying a few simple compounds in detail is pursued until the student is more or less familiar with representatives of all the principal groups of compounds derived from the paraffins. He is now in a position to study these hydrocarbons as a group, and to deal in some detail with the questions of isomerism. When the paraffins and their derivatives have been thus studied, the more difficult subject of the benzenes and their compounds is approached. And here the author shows an admirable power of dealing with facts as facts, and with theories as theories. What could be better than the following remarks regarding saturated and unsaturated compounds?

"In the aldehydes and ketones, carbon is in combination with oxygen in the carbonyl condition. When they unite with hydrogen and some compounds, such as hydrocyanic acid, the relation between the carbon and oxygen is probably changed, the latter being in the hydroxyl condition. The changes are usually represented by formulas such as the following:—



In the carbonyl group the oxygen is represented as held by two bonds to the carbon atom, while in the hydroxyl condition it is represented as held by one bond. The signs may be used if care is taken to avoid a too literal interpretation of them. There are undoubtedly two relations which carbon and oxygen bear to each other in carbon compounds. These relations may be called *the hydroxyl relation*, represented by the sign C—O—, and *the carbonyl relation*, represented by the sign C=O" (pp. 209–10).

How different this is to the crude, glaring statements that annoy the reader of the commonplace text-book written by the Philistine.

The fact that structural formulæ help us to understand the relations existing between the parts of specified mole-