His scientific labors began early in life and were continued up to the present year. They were devoted especially to the study and description of recent shells and the fossil shells of the Tertiary and Cretaceous formations of the United States; and in the Tertiary species they exceed in importance those of any other American Paleontologist excepting Mr. Meek. As early as 1832 he published the first number of an illustrated work on the "Fossil shells of the Tertiary formation," which, however, was never completed; and in 1831 began his "American Marine Conchology," which he carried to 72 pages and 17 plates. Later his papers were published from time to time in this Journal, and in the Publications of the Academy of Sciences of Philadelphia; the first communication to this Journal appearing in 1833, and the last in February, 1877. Memoirs by him are also to be found in the reports of various surveying expeditions. Between 1835 and 1841 he issued thirteen numbers of a "Monography of the Family Unionidæ," with many colored plates. In part of his publications he was his own lithographer. During the years 1838 to 1841, Professor Conrad had charge of the Paleontological department of the Geological Survey of New York, and his Annual Reports for those years and the Journal of the Philadelphia Academy for 1842, contain descriptions of many of the species discovered—the larger part of all that were known previous to the labors of Professor James Hall, into whose hands this department fell in 1843. Some of his general geological conclusions are presented in his "Notes on American Geology," published in this Journal for 1839 (vol. xxxv, 237), in which he advocates the doctrine (which Agassiz first suggested) that the grander divisions of geological time, or abrupt transitions in life, were determined by cold intervals in the course of the earth's progress, and he points out the great fact that the Mississippi depression, as it is often called, was a consequence of the elevation of the Appalachians on the east, and of the Rocky Mountain area, late in geological time, on the west. On the first of these points he remarks that "the theory of periodical refrigeration alone can explain the sudden extinction of whole races of animals and vegetables."

Professor Conrad took a most important part in laying the paleontological foundations of American Geology—a work shared largely also by Lea and Lyell as regards the Tertiary, by Morton for the Cretaceous, and, still more largely, by Hall for the Paleozoic species, and carried forward later by other able paleontologists.

Robert Were Fox, F.R.S., died on the 25th of July, in the eighty-eighth year of his age, "having spent his long life in acts of usefulness and deeds of the purest Christian benevolence." His experiments on the temperatures of deep mines proving an increase of depth downward, on the electro-magnetic properties of mineral veins, and his construction of the first dipping needle, are among the important scientific works that have given his name a world-wide reputation. "To his latest days, in the retirement of his beautiful home, he delighted to surround himself with intellectual friends," and watched with unfailing interest the progress of scientific discovery.

APPENDIX.

Art. XXXIII.—*Notice of some new Vertebrate Fossils;* by O. C. Marsh.

The specimens described in the present article are all from the Rocky Mountain region, and include Mammals, Birds, Reptiles, and Fishes. Among the Mammals are two Miocene Edentates, the first detected in this country, and a third species of this group from the lower Pliocene. Another Mammal of much interest is a Rhinoceros from the Eocene, the oldest known member of the family. A number of new genera are introduced, some of which have an important bearing on the genealogy of Tertiary Mammals. Among the other vertebrates is a new genus of Crocodilians from the horizon of the Wealden, and a species of *Crocodilus* from the Pliocene.

Moropus distans, gen. et sp. nov.

This genus of Edentates is based mainly upon the bones of the feet, which have been found in several individuals. These remains are quite different from the feet bones of any of the American Edentates, recent or fossil; but indicate affinities with the extinct *Ancylotherium*, from the Tertiary of Europe, which is supposed to be related to the African Ant-bear (*Orycteropus*). The specimens here described belong to a distinct family, the *Moropodidæ*.

In the type specimen of the present species, only the hind feet appear to be represented. One of the most characteristic bones is a coössified first and second phalanx. The articulation for the metatarsal is nearly in a horizontal plane, and situated on the proximal end of the upper surface of the base. It is somewhat heart-shaped in outline with the apex rounded and about equally concave in both directions, or slightly less so transversely. This articulation occupies nearly half the length of the first phalanx which is thoroughly coössified with the second. The line of junction between the bones can, however, be traced easily, and is strongly marked on the under surface by a pit or foramen entering obliquely upwards and forwards. Except near this line of junction, the surface of the

bone is rather smooth. The under surface, below the articulation, is flattened. The second phalanx is less than half the length of the first, and its surface is roughened, as if by abnormal growth of bone over the surface. The length of the first phalanx is 43mm; the longitudinal diameter of the metacarpal articulation 18mm; its transverse diameter 23mm. The least transverse diameter of the bone is 21mm: its vertical diameter at the middle is 20mm. The second phalanx is broken in this specimen, its distal articular face being absent.

Associated with the above specimen, is a short bone evidently a median phalanx, with both articular surfaces well preserved and in form corresponding to each other. Proximally there are two grooves separated by an intermediate ridge, and distally two pulley-shaped ridges with a deep groove between. The length of the shaft of this bone is 23mm; its transverse diameter is 21mm proximally, and 17mm distally. Near the center of the terminal pulleys is a deep pit on each side. The greatest vertical diameter of the bone is 32mm. This bone resembles the penultimate phalanx of the middle finger of *Priodontes*, but is somewhat shorter and thinner.

These and other less characteristic remains indicate an animal somewhat larger than a tapir. They were found in the Miocene of Oregon by the Yale Expedition of 1873.

Moropus senex, sp. nov.

A second larger species of the same genus is indicated by a few remains, among which is the characteristic bone formed of the united phalanges. The proximal phalanx is considerably larger than the one above described. Its length is 52mm. The proximal articulation is oblique, and does not occupy more than one-third the upper surface of the bone. The median phalanx is well preserved, and measures 25mm in length. It is not united with the first phalanx in a line with the axis of that bone, but is inclined about 15° toward the sole of the foot. Its distal articulation is composed of two not very prominent pulley-shaped surfaces with a groove between.

Moropus elatus, sp. nov.

The largest species of this genus, now known, is represented at present by a number of bones of the posterior extremities, mainly from the feet. The peculiar duplex bone already mentioned is among them, and affords means for comparing the different species.

The proximal phalanx here measures about 90mm in length, and the medial one 40mm. The articulation for the metatarsal is more nearly vertical than in either of the Miocene species. Its median vertical diameter is 30mm; and transverse diameter

42mm. The least vertical diameter of the phalanx is 28mm; transverse diameter 31mm. The second phalanx has a transverse diameter of 32mm, and a vertical diameter of 49mm, measured across the curve of the terminal pulley. The least vertical diameter is 38mm.

Associated with this bone is a well preserved first metatarsal, measuring 135mm in length. Its minimum transverse diameter is 25mm. The proximal surface is subtriangular, with the external side of the triangle curved outward, and the other shorter sides somewhat curved inward. The external three-fourths of the surface is transverse, and occupied by a nearly flat articular surface, which rises along a vertical ridge near the inner margin of the face. Beyond this ridge, the upper part of the surface shows marks of articulation with another bone. The inner face of the bone is somewhat concave proximally; it then presents a low broad elevation, and is flattened distally. The shaft of the bone is rounded throughout. The distal articulation is hemispherical above, but presents two shallow grooves below, which are carried around so far as to become nearly horizontal. The greatest proximal diameter is 50mm, and the greatest distal diameter 44mm.

The proximal face of the fifth metatarsal is oblique, triangular in outline, convex vertically, and through the greater part of its tranverse extent. Its greatest vertical extent is 65mm, and greatest horizontal diameter the same. The vertical diameter of the shaft of this bone is 40mm, and its transverse diameter 38mm. The calcaneum measures 108mm from its posterior end to the vertical face for articulation with the astragalus. The vertical diameter of the shaft is 53mm, and the transverse diameter 41mm.

These remains are from the Lower Pliocene of Nebraska, and indicate an animal about as large as a Rhinoceros.

Amynodon, gen. nov.

The present genus is based upon a nearly perfect skull, and various other remains which belonged to the oldest representative of the Rhinoceros family yet discovered. These specimens are from the Uinta or *Diplacodon* beds, of the Upper Eocene, and about the horizon of the Paris basin. The skull is intermediate in form between that of a Tapir and a Rhinoceros, but the molar teeth are entirely of the latter type. The premolars are all unlike the molars, and the canines above and below are very large. The incisors are small, and the inner one in each jaw is lost in the present adult animal. The lower canines are placed nearly horizontal, and taken in connection with the rest of the anterior dentition, they prove conclusively that the large lower teeth, usually regarded as incisors

in *Acerotherium* and many other members of the Rhinoceros family, are really canines.

The nasals in this genus are smooth, and evidently were without horns. There were four toes in front and three behind. The type species is *Amynodon advenus* Marsh, which was provisionally referred to the genus *Diceratherium* when first described.

Tapiravus rarus, gen. et sp. nov.

The paucity of Tapiroid remains in the Miocene and Pliocene lake basins of Western America is a singular fact, probably due in part to temperature, and in part to the nature of the surrounding country. The few specimens found have been referred to *Lophiodon*, a Lower Eocene genus. Various remains from these formations on the Atlantic coast and in the West show, however, that they are quite distinct from *Lophiodon* and the existing Tapir, and represent an intermediate genus, which may be called *Tapiravus*. The type species is *T. validus* Marsh, (*Lophiodon validus*) from the Miocene of New Jersey. This genus may readily be distinguished from *Lophiodon* or *Hyrachyus*, by the last upper premolar, which is similar to the adjoining molars.

A second species of this genus occurs in the Lower Pliocene east of the Rocky Mountains, and remains were collected there by the writer in 1873. The most characteristic specimen obtained was an upper molar tooth which indicated an animal considerably smaller than the living Tapir. The crown of this molar was 15^{mm} in antero-posterior diameter, and 17^{mm} in transverse diameter. It is peculiar in having the antero-exterior angle very obtuse, and less prominent than the outer cusps.

Bison ferox, sp. nov.

This genus has not hitherto been found in the Tertiary of this country, although not uncommon in later deposits. The Museum of Yale College contains two well preserved horn-cores from the later Tertiary, one of which was found by the writer in the lower Pliocene of Nebraska. This is quite as low as the genus has been found in the Old World. This specimen indicates an animal much larger than the existing Bison, and having very powerful horns. The specimen preserved was over 500^{mm} in length, when complete. The radius of the inner curve measures about 400^{mm}. The largest end has a diameter of 125^{mm}, and the smaller, at a distance of 300^{mm}, measures 77^{mm}.

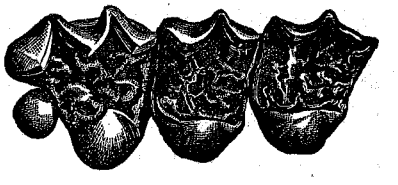
A second larger species, with more curved horns, is indicated by a nearly perfect horn-core from the lower Pliocene of Kansas. This species, which may be called *Bison Alleni*, in honor of Dr. J. A. Allen, of Cambridge, also had very large

horns. The type specimen has its greatest and least diameters near the base, 140^{mm} and 110^{mm}. At a distance of 300^{mm} further toward the end, the diameters are 100^{mm} and 90^{mm}. The radius of the inner curvature, except for the last 150^{mm} of the length, was 350^{mm}.

The discovery of these two lower Pliocene species of Bison, suggests the probability that this form is a New World type, although it has generally been credited to the other hemisphere.

Allomys nitens, gen. et sp. nov.

Among the Upper Miocene mammals, a peculiar genus is found, which is probably related to the flying squirrels, but the teeth are somewhat like those of Ungulates. Its affinities are evidently with the Rodents, however, and it represents a distinct family, the *Allomyidæ*. The general characters of the upper molar teeth are shown in the accompanying figure,



which is six times natural size. The animals of this species are all very small, hardly larger than a rat. The extent of three molar teeth is 8^{mm}. The transverse distance between the two series is, in front, 3·8^{mm}, and posteriorly, 4·4^{mm}.

The known remains of this species are all from the Upper Miocene of Oregon.

Graculavus lentus, sp. nov.

The Cretaceous deposits of the Atlantic coast and of Kansas have hitherto alone yielded remains of Birds, but these have recently been found in beds of the same age in Texas. The most characteristic specimen obtained is the distal end of a metatarsal, which differs from the corresponding bone of the toothed birds from Kansas, and may be referred provisionally to the genus *Graculavus*, the type of which is from the Upper Cretaceous of New Jersey. This specimen shows that there were three toes of nearly equal size, and also a hallux raised above the main digits.

Transverse diameter of shaft of tarsometatarsal bone	4·2^{mm}
Vertical diameter of same	3·6
Transverse diameter across distal articular faces	10·
Vertical diameter of median distal articular face	4·8

The known remains of this species indicate a bird about as large as a small duck.

Diplosaurus felix, gen. et sp. nov.

An interesting discovery recently made in the lower Cretaceous, or Wealden beds, of Colorado, is a new genus of Crocodilians, intermediate between the old Teleosaurian type and the modern *Crocodilus*. The new genus has a head and teeth very similar to the latter, but with this the ancient biconcave vertebræ. The present type species is based upon a nearly perfect skull, and a number of vertebræ belonging with it. These pertained to an animal smaller than most existing Crocodilians.

Some of the principal measurements of this species are as follows:

Length of skull on median line	255·mm
Length of skull from quadrate to end of snout	275.
Transverse diameter of premaxillaries	46·
Transverse diameter of skull, at front of orbits	90·
Transverse diameter at ends of quadrates	122·
Transverse diameter of quadrate at end	20·

A second species of this genus is apparently the *Hyposaurus Vebbii* Cope, which may be called *Diplosaurus Vebbii*.

Crocodilus solaris, sp. nov.

No Miocene Crocodilians are known from the Western lake-basins, and none have been described from the Pliocene of the same regions. One species, however, lived in the Pliocene lake east of the Mountains, and, as an indication of climate, at least, is well worthy of record. The remains preserved indicate an animal of moderate size, well protected with deeply pitted bony plates, and probably belonging to the genus *Crocodilus*.

Measurements of some of the more important remains are the following:

Length of centrum of lumbar vertebræ	42· mm
Vertical diameter of anterior articulation	25·
Transverse diameter	30·
Vertical diameter of neural canal	11·
Vertical diameter of posterior articulation	25·
Transverse diameter	30·
Transverse diameter of dermal scute	34·

These specimens were found by the writer, in 1873, on the Niobrara River in Nebraska.

Nanosaurus agilis, gen. et sp. nov.

The most diminutive Dinosaur yet discovered is represented by various portions of a skeleton recently received from the Mesozoic deposits of the Rocky Mountains. These remains indicate an animal not larger than a cat, and yet apparently fully adult. Most of the bones are hollow, and the walls thin.

The crowns of the teeth are apparently compressed, and inserted in distinct sockets. The femur has the characteristic third trochanter, and is shorter than the tibia.

The principal dimensions of this pigmy Dinosaur are as follows:

Space occupied by five teeth in lower jaw	13· mm
Depth of jaw below last tooth	10·
Length of femur	63·
Distance from head to middle of third trochanter	25·
Length of tibia	75·
Least diameter of shaft	6·

The geological horizon of this unique fossil is probably Jurassic, but possibly in the lower part of the Dakota group, which I regard as the equivalent of the Wealden of Europe.

Nanosaurus victor, sp. nov.

Another small Dinosaur, which may be provisionally referred to the same genus, is indicated by portions of a skeleton found in the same region, and probably at or near the same horizon. These remains belonged to a reptile about twice as large as the one just described. The bones are equally hollow, and the walls very thin. The tibia is much more elongated, and slender. No teeth were found with this specimen. The length of the tibia was about 100^{mm}, and the diameter of its shaft at the middle 6^{mm}. A metatarsal bone measures 41^{mm} in length. The remains at present known indicate an animal about as large as a fox.

Apatodon mirus, gen. et sp. nov.

One of the most interesting specimens hitherto found in the Rocky Mountain region, is a portion of a lower jaw with the last molar in place. This fossil is widely different from anything yet described, and its exact affinities are doubtful. The fragment pertained to an animal about as large as a Tapir, and the general appearance of the specimen at once suggests the mammalian type. The tooth most resembles, in form and superior surface of crown, that of a typical Suilline. The structure of the tooth, however, is different, and the fangs are, in part at least, coössified with the jaw.

This specimen was found near a locality where Dinosaur bones were abundant, and it is possible it may belong with that group. The jaw, however, is very unlike any corresponding jaw of a Dinosaur, so far as now known. This tooth measures about 41^{mm} in length of crown; 20^{mm} in transverse diameter, and 8^{mm} in height. The geological horizon is Lower Cretaceous or Jurassic.

Heliobatis radians, gen. et sp. nov.

The most interesting fossil Fish hitherto found in the Tertiary of the west is a land-locked Ray, recently discovered in the Green River beds of Wyoming. The specimen is in excellent preservation, and shows the characters of the group most perfectly. It differs much from recent Rays, and resembles most nearly the genus *Cyclobatis* of Egerton, from the Mt. Lebanon deposits of Syria, which are probably in nearly the same horizon as the locality of the present specimen. The latter differs from *Cyclobatis* in having a much greater number of radiating digits, which entirely encircle the body, and suggested the generic name. There are also numerous dermal defensive tubercles, which are wanting in *Cyclobatis*.

The principal dimensions of this rare specimen are as follows:

Antero-posterior extent of rays	235·mm
Transverse diameter across scapular arch to bases of rays	75·
Total transverse diameter	220·
Transverse diameter of head	82·
Distance between scapular and pelvic arches	55·
Length of vertebræ at pelvic arch	2·6
Length of vertebræ in caudal region	2·

Yale College, August, 1877.

THE

AMERICAN

JOURNAL OF SCIENCE AND ARTS.

[THIRD SERIES.]

ART. XXXIV.—*On the relations of the Geology of Vermont to that of Berkshire;* by JAMES D. DANA.

[Continued from page 207.]

2. LITHOLOGICAL CONCLUSIONS: WITH SPECIAL REFERENCE TO THE USE OF LITHOLOGICAL CHARACTERS AS A TEST OF GEOLOGICAL AGE.

IT is sometimes laid down as a canon in geology that the age of a crystalline terrane or formation can be told from the kind of rock constituting it. Thorough knowledge as to the kinds that may exist in formations of the same age is the proper basis for such a canon—if it has a basis—and a test of its value. The limestone series affords important facts on this subject.

The Taconic slate-belt in the western half of the limestone area and the quartzyte group of the eastern half may be separately considered, and, afterward, the relations of the two.

1. *Taconic slate-belt or range.*

The diversity of rocks in the Taconic slate-belt is small compared with that in the Eastern or Quartzyte group.

A. *In Vermont.*—The rocks, as has been explained, are (1) *argillyte* to the north; then argillyte along the center with borders of (2) *hydromica slate* varying from a pure slaty hydrous mica to a mixture of hydrous mica with more or less quartz; (3) *chloritic hydromica slate*, in which quartz seams and veins (often chloritic) are common. Besides these, there is (4) a *hydromicaceous conglomerate*, consisting of quartz pebbles in a