A Fossil-collecting Campaign in New Mexico

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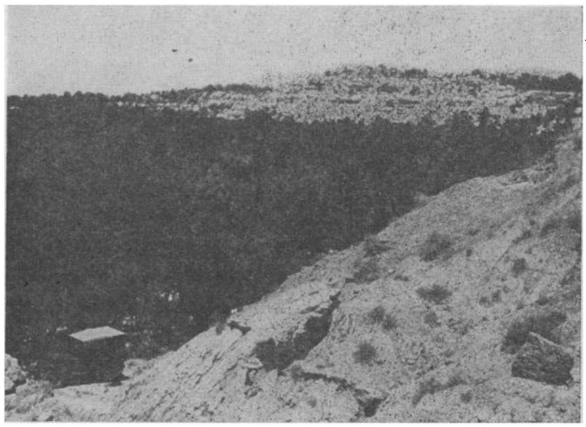
IN NORTHWESTERN NEW MEXICO a tremendous segment of the history of the earth and of its life lies open to him who can read it. Here, where massive San Pedro Mountain now rises, a Paleozoic sea can be seen beating on a granite shore. As the sea retreats, the most ancient of reptiles wander into the lowlands. Drought sets in for a time, but ungainly phytosaurs still swarm in the streams that cross the plains, and small, earliest dinosaurs scamper across the landscape. The sea comes again. Great forests grow up along its coast, while, offshore, real sea serpents cruise. Dinosaurs return again and again as land emergence predominates over marine invasion, and these reptiles become ever more varied, more bulky, and more grotesque.

The sea makes a final retreat and leaves a low basin into which complex river systems flush great masses of banded sediments. The dinosaurs disappear forever from the scene, and in their place come invading hosts of mammals, some as tiny as shrews and none, at first, larger than sheep. The land rises slowly, in broad waves, until the region lies a mile or more above the sea that once swept over it. Here and there volcanoes repeatedly break out and spread their ash and lava far and wide. Locally, the crust buckles and thrusts up mountains, 10,000 feet and more in elevation. As the land rises, the whole region, once more semiarid, is deeply carved by canyons and sculptured in many places into badlands and scarps, revealing the record of all these events.

It would be difficult to say which chapters in this history are most exciting or most important for an understanding of our world and its life. Two, however, have lately seemed of special interest for detailed investigation, because they are crucial parts of the history and because they have not been sufficiently understood. These are the chapters labeled geologically as the Triassic period and the Eocene epoch. Separated by perhaps 115,000,000 years, they are analogous in representing corresponding stages in two successive major cycles of the evolution of life.

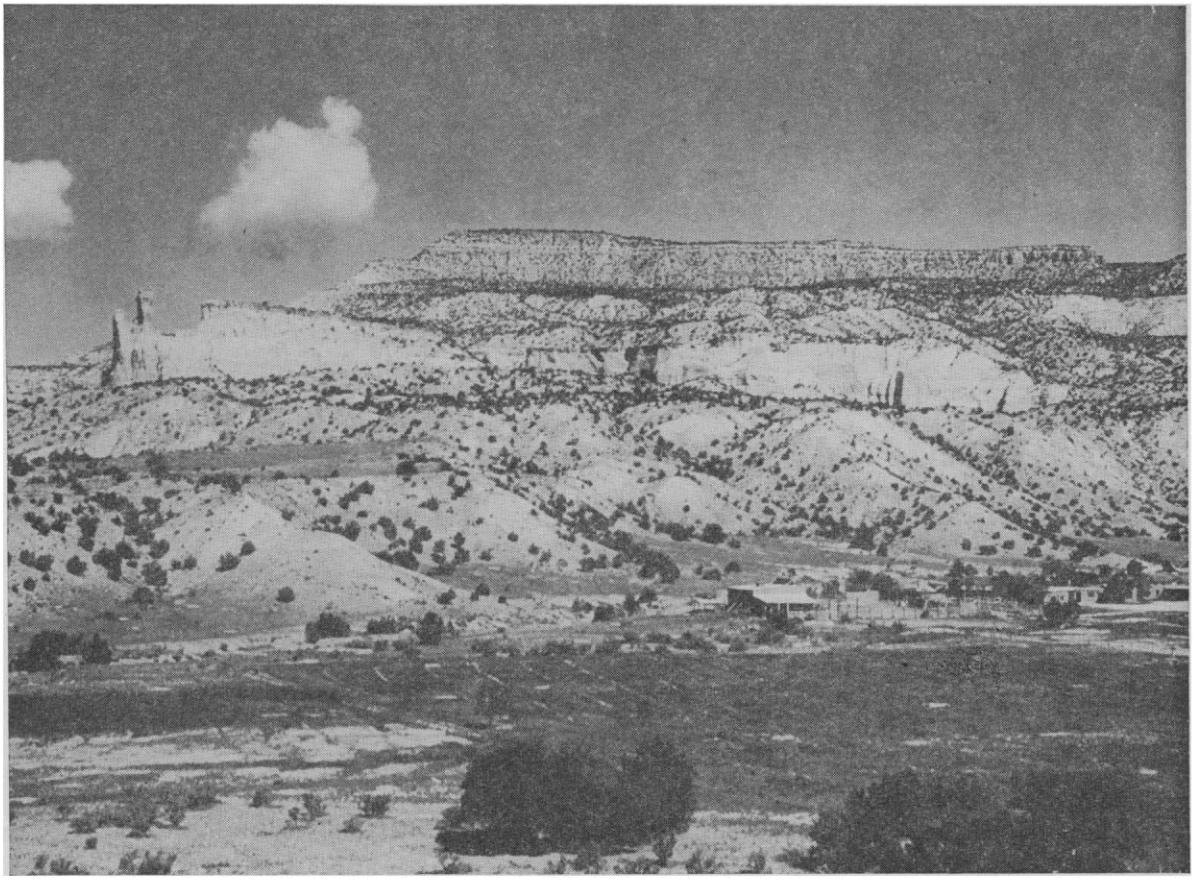
Reptiles had arisen and had, indeed, become abundant before the Triassic, but that period marks a turning point in their history. It was the time when, on one hand, the roots of our present reptilian orders (such as turtles, lizards, crocodiles) were being differentiated and, on the other, the characteristic, now extinct forms (such as dinosaurs) of the medieval world were becoming dominant. Similarly, there were mammals long before the Eocene and they had become rather abundant and varied in the preceding epoch, the Paleocene, but the Eocene was more truly the beginning of our modern, mammal-dominated world. The groups of future promise, such as the primates, rodents, and modernized ungulates, were achieving their basic patterns, and the archaic mammalian grotesques, slated for extinction, were in their prime.

It was, then, for the Triassic and Eocene of northwestern New Mexico that we headed in the summer of 1947 with two small cooperating parties from



Discovery site of Eocene mammals, especially *Meniscotherium*, at head of north branch of Oso Arroyo, northeast of Lindrith, New Mexico. A quarry entry is visible in the red clays near the top of the slope in the right foreground. Pinyon-juniper forest extends to the base of the exposures and makes access, even by jeep, difficult. (*American Museum photo by G. G. Simpson.*)

the American Museum of Natural History. As advance guard, William E. Fish and George O. Whitaker, of our laboratory staff, went out in May and set up a base camp almost on top of the continental divide, on the isolated E. M. Collins Ranch at the head of Yegua Canyon, some 10 miles (as the crow flies) north-northeast of the small settlement of Lindrith. This is in the Eocene area, and Fish and Whitaker started prospecting those deposits once they had our equipment on the spot and tents set up. Snow falls late at these elevations (around 8,000 feet), and they found it less acceptable than did David Baldwin, a pioneer predecessor of theirs in this general region during the 1880s. Baldwin used to prospect in winter by preference, wandering



Ghost Ranch, near Abiquiu, New Mexico. The lower hills back of the ranch buildings are in the Chinle formation, in which late Triassic dinosaurs were found. The middle vertical cliff is the Wingate sandstone, capped by the relatively thin gypsum of the Todilto formation, Jurassic in age. The high, distant slopes are in the late Jurassic Morrison formation, and the high mesa is capped by the Cretaceous Dakota sandstone. (*American Museum photo by E. H. Colbert.*)

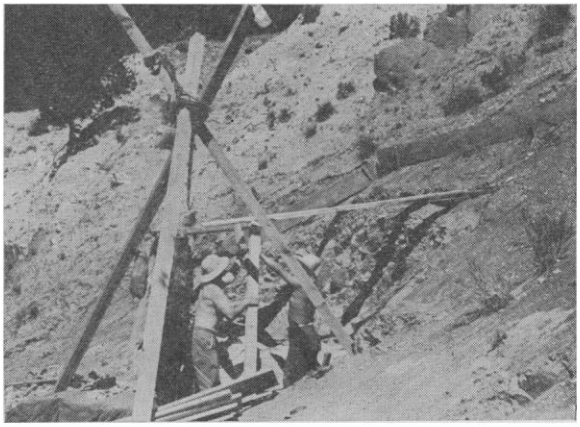
through the San Juan Basin with a pack burro, depending on snow for water. Our jeeps will go anywhere his burro could, and they keep us in touch with water, so that we can try to avoid the snow.

Early in June, Edwin H. Colbert, the Museum's curator of fossil reptiles, amphibians, and fishes, Thomas Ierardi, of the College of the City of New York, and I joined Fish and Whitaker. After a few days of looking over the Eocene prospects around camp, we set out to locate a promising Triassic area for the other phase of the summer's work. This was soon located on the Ghost Ranch of Arthur Newton Pack, long editor of *Nature Magazine* and an extremely helpful friend of the American Museum. Here Colbert, Ierardi, and Whitaker were given field quarters of incredible luxury, including a large house complete with indoor plumbing and a swimming pool. Fish and I enviously read them out of the bone-diggers union! The Ghost Ranch is located about 15 miles northwest of the old Spanish town of Abiquiu (David Baldwin's headquarters in the last century) and backs up against one of the great scarps that make this region breathtakingly picturesque for the tourist and incomparably instructive for the geologist.

When the extent of their discoveries made them call for help, the Ghost Ranch swimming team (as Fish and I dubbed our lucky colleagues) was joined by Carl Sorensen, of the Museum laboratory. Meanwhile Fish and I returned to our lonely camp and turned to on the Eocene. Later in the summer we were joined by my wife, Anne Roe, and moved to the vicinity of Regina, where we, too, enjoyed the luxury of a house.

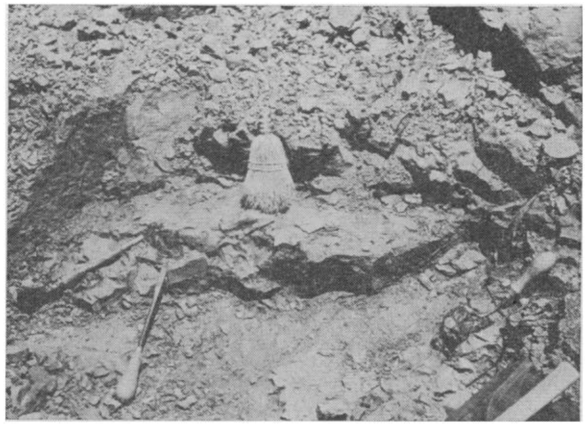
It is seldom that a bone-digger decides to hunt for one particular sort of animal. If he does, still more seldom does he succeed. We set out, as a rule, to find whatever we can in a particular area or a particular geological formation. The burial and preservation of ancient animals are so capricious that we necessarily let fate decide precisely what we will collect. The most extraordinary thing about last summer's campaign was not only that both Colbert and I had in mind quite definite preferred discoveries when we set out but also that we actually made these discoveries, and in almost embarrassing abundance. I wanted the mammal ***Meniscotherium*** and he wanted the dinosaur *Coelophysis*. (He pronounces the latter name seel-o-fy′-siss and I pronounce it see-loff′-iss-iss; he is the dinosaur expert.)

Coelophysis was found in the first few days of prospecting on Ghost Ranch. Whitaker was prospecting in the Chinle beds, red shales (for the most part) of late Triassic age forming the sloping base of the great scarp, when he found several small, broken bones, washed out and scattered on the steep hillside. The whole party quickly concentrated on the discovery, and the layer containing the original deposit was soon located. This layer proved to be sensationally rich, probably the most important single discovery ever made in the American Triassic. A bed a foot or two thick was found to be jammed full of bones of the little dinosaurs, piled one on top of the other and crisscrossed in every direction. More surprising still, for such an accumulation, the great majority of the bones seem to be associated in virtually complete skeletons, articulated as in the living animals.



Erecting a shelter over the newly opened Triassic dinosaur quarry on the Ghost Ranch, for shade and to protect the bones from rain and slides. The tripod is for block and tackle to turn and move the heavy blocks. ***(American Museum photo by E. H. Colbert.)***

The total number of skeletons in the deposit is unknown, but there are certainly dozens and possibly hundreds. In 1947 the bone layer was followed for over 20 feet along the outcrop and exposed by stripping the overburden to a distance of about 10 feet from the face of the exposure. In this area 18 skulls were seen, with correspondingly numerous bones of other parts of the skeletons, and others are being revealed as the blocks are prepared in the laboratory in New York. Following usual collecting practice, no attempt was made to clean any of the bones in the field, and no more were exposed than necessary. The whole mass, bones, shale, and all, was separated into blocks of manageable size which were then covered with plaster and burlap, with wooden braces, and transported bodily to New York. Because the skeletons are so closely packed that no bone-free channels could be found, the separation of the blocks was an exceptionally difficult and trying operation. Only the consummate skill and patience of Colbert and his aides permitted removal without irreparable damage to many of the skeletons.



Close-up of digging site. ***Meniscotherium*** **bones, which are colored like the red clay that encloses them, are difficult to see in the field or in a photograph. There are bones below each of the brushes and at the end of the curved awl and chisel-like digger.** ***(American Museum photo by G. G. Simpson.)***

No one, including ourselves, has yet clearly seen a complete, assembled *Coelophysis* skeleton, but the general characters of the animal are already clear. It was small, as dinosaurs go—perhaps 6 feet from the tip of its wedge-shaped head to the end of its slender tail—and lightly built and hollow-boned throughout, probably not exceeding 50 pounds in live weight. It was bipedal, normally walking on its three-toed, strongly clawed hind feet, although the smaller front limbs were still functional. The sharp, recurved teeth indicate carnivorous habits.

Discovery of the *Coelophysis* quarry necessarily stopped all other work in the Triassic for the summer. We were able to take *Meniscotherium* more in our stride. Fish and Whitaker had already found some scraps of this beast before the rest of us arrived. Fish and I continued to search the red banded clays on the west side of the continental divide and continued to find some scattered *Meniscotherium* fragments, along with similarly incomplete remains of various other fossil mammals. Pickings are usually quite thin in these Eocene beds. It is all too common to search all day without finding anything worth keeping, and half a dozen jaw fragments with two or three teeth in each is a big day's haul. The bones were so scattered before they were buried that fragments occur widely separated and singly. They are found as they erode out, or after this, and digging into the undisturbed clay is usually futile.

One day, however, Fish and I simultaneously found a place on the Wayne Hatley Ranch where fragments of *Meniscotherium* were so extraordinarily numerous in the wash that it was evident that there must be an unusual concentration of them somewhere in the clays outcropping on the slopes above. Before long we had found the right layer and started to quarry into it in two places. The skeletons were not articulated, as in the case of *Coelophysis,* but had become separated as they were buried. Most of the bones found were, however, complete, and every bone in the skeleton was represented many times over, from perfect skulls with all the teeth down to sesamoids smaller than the grain for which they are named. Thus, we will have each separate skeletal element in perfect condition for study and for assembling into reconstructed whole skeletons. Our collecting problem was physically much simpler than for *Coelophysis,* because the animals are smaller and the bones occur separately. Here, again, we do not know how many individuals are represented in the whole deposit, but there are dozens, at least.

Meniscotherium was a small mammal, probably about 10 inches high and little over 2 feet from the nose to the tip of the fairly long tail. The relatively large head was about 5 inches long. There were 4 stout, nearly equal legs, each foot 5-toed, and each toe ending in a compressed, almost claw-like, tiny hoof. The animal is so primitive as to look almost like a diagram of a generalized mammal, but it has one striking anatomical peculiarity: the cheek teeth have sharp, crescentic crests, an herbivorous specialization that had not yet been achieved by any other known group of animals in the early Eocene.

Within two weeks we had collected as many *Meniscotherium* bones as the New York laboratory could cope with during the winter. We discontinued quarrying there for that summer and resumed the general program of scouring the Eocene exposures systematically for as complete and varied a representation of their whole fauna as can be obtained. In this work the rare quarry concentrations are caviar (no one ever found any there before our work in the New Mexican Eocene), and the long grind of prospecting for isolated specimens is the daily bread. Precise identifications have not yet been made, but we estimate that we have well over 50 species, some of them evidently new, and we know, in a general way, that the following groups are included: gastropods (land or fresh-water snails), fish (gars, *Lepidosteus*), lizards, snakes, crocodiles, turtles, and more or less abundant representatives of at least 10 mammalian orders including Insectivora, Primates, Tillodontia, Taeniodonta, Rodentia, Carnivora, Condylarthra, Pantodonta, Perissodactyla, and Artiodactyla—a varied and promising haul.

The purpose of this field work is not only to obtain fossils, but also to make more direct geological studies of the beds in which they occur. The levels of fossils within the beds are determined and recorded as a matter of routine. Other work is directed toward such problems as the subdivision of the strata, their precise correlation with beds elsewhere, their physical nature and mode of origin, or the dating of mountain-making and other earth events in this region. Progress toward the solution of these and related problems in 1947 involved measuring a number of thick cross-sections of the beds, discovery of age-determining fossils in supposedly barren low levels of hitherto disputed age, determination of structural relations in the zone of tilting along the mountain flank (the Nacimiento uplift), and other stratigraphic study. (A paper summarizing preliminary stratigraphic results of work in 1946 and 1947 is now in press.)

Just as the season was closing and we were preparing to pack up, Dr. Roe found another small concentration of bones still in the rock. This was on the other side of the continental divide from the *Meniscotherium* quarry and at a lower level which contains a recognizably different fauna. The unusual feature of this find is that it includes, in addition to eohippus (*Hyracotherium*), which is among the less rare fossils at this level, remains of several different very diminutive mammals. The difficulty of finding these tiniest, shrew-sized members of the fauna makes them among the least well-known of fossils. We had time to collect only a sample from this bed and then covered it carefully to protect it from weathering and left it for next summer.

Paleontologists must necessarily be patient. There are few subjects in which so much time must usually elapse between a discovery and its proper realization. This is a point which, quite naturally, tends to elude the public and the press. The moment when a fossil is news seems to be when it is first seen in the field. Actually, at this point the significance of the find is seldom known, and it is often impossible to say then whether a really new contribution to science has, in fact, been made. Evaluation of the find and its true news value usually develop gradually and over a period of years, during which timeliness in the usual conception of the press has evaporated.

The discoveries reviewed here are no exception to this rule, and their discussion as news some months later may seem out of date to the reader but still seems premature to the writer. The finds are, at least, striking enough that we feel sure they will result in important additions to knowledge. That result is, however, still far in the future. Four skillful preparators (Walsh, Sorensen, Whitaker, and Fish) are working on the bones. Matrix must be picked off, grain by grain, from tiny mammal jaws under a microscope. The jackstraw piles of *Coelophysis* skeletons must be disentangled with extreme care not to damage the hollow, often paper-thin bones. It will be several years before the collections as a whole can be in shape for proper study. In the meantime, the field campaign is not complete. It will not be necessary or advisable to clean out all the bones from the quarries that we have discovered, but we will have to return to them in 1948 in order to have adequate suites for our study, and, eventually, for exhibition here and in other museums, as well. More years of field work will be required for elucidation of the general problems to which these particular discoveries contribute only some details.

It is, indeed, the most important thing about these finds that they are not isolated, chance discoveries, but are episodes in a long, planned program in particular fields, which in turn is a consciously integral part of the whole grand effort to understand the nature of life and its history.

As regards *Coelophysis* and *Meniscotherium,* specifically, both of these animals have been known, imperfectly, for a long time, and the finds resulted from deliberate effort to complete this knowledge. The first fossil collector in this region and the first student of these faunas was Edward Drinker Cope, who examined both the Triassic and the Eocene of New Mexico as early as 1874 and in that year found and named *Meniscotherium.* Some remains of *Coelophysis* were described by Cope in 1887, and this name was applied to them by him in 1889.

The fragments known to Cope showed that *Coelophysis* was a small dinosaur similar in some respects to later, somewhat bird-like forms such as *Coelurus* of the late Jurassic. He had no trace of the skull or jaws, and the skeletal remains available before 1947 were far too incomplete to give much idea of the animal as a whole or of many of its essential characters. Triassic dinosaurs in general have been found scattered in various parts of the world—the Connecticut Valley, Germany, South Africa, China, Brazil—but they remain relatively rare and inadequately known fossils. From them must be learned how the dinosaurs originated and became split up into their highly diverse lines of descent, a problem of exceptional popular and technical interest. *Coelophysis,* one of these dinosaurian forerunners, is now destined to be among the most completely known of all fossil animals.

Meniscotherium was better known than *Coelophysis* even before our recent discoveries. Jaw fragments were not rare, and fairly good series of them were available in several museums, especially the American Museum and the Peabody Museum at Yale. There were several known skulls, crushed and incomplete but still reasonably well preserved as Eocene fossils go. An attempt had even been made at the American Museum to reconstruct the whole skeleton from parts collected by David Baldwin for Cope. Our vastly better and more complete series of specimens collected in 1947 has already demonstrated that this reconstruction was grossly incorrect in several important particulars—another painful lesson that, Cuvier and the popular impression to the contrary notwithstanding, paleontologists cannot correctly restore missing parts of ancient animals unless the parts are known in closely related forms.

Meniscotherium has no known close relatives, and its wider affinities are very uncertain. This is, of course, a main reason why I was so anxious to obtain better materials for study of the genus. Two inadequately known genera (*Pleuraspidotherium* and *Orthaspidotherium*), found only on one small hill near Rheims, France, may really be sufficiently related to *Meniscotherium* to justify the usual reference of them to the same family, but they are markedly unlike the American genus in some respects. Cope thought at first that *Meniscotherium* was a perissodactyl, related to eohippus and the other horses and their allies, but he later placed it in the Order Condylarthra. There has been little more evidence for this view than that *Meniscotherium* is a primitive herbivore, and so are the typical condylarths. Most later students have followed Cope without any real re-examination of the problem and apparently without any strong conviction. Marsh, who never followed Cope if he could help it, did propose placing the meniscotheres in a separate order of their own (Mesodactyla), but no one else followed this suggestion or even gave it the attention that it may deserve.

Several students have remarked in passing that *Meniscotherium* might be related to the hyraxes or to the litopterns. Hyraxes, fossil and recent, are confined to the Old World and are of unknown origin. Litopterns, extinct ungulates, some of which paralleled the horses in their evolution, are known only in South America and apparently arose from condylarths. If the North American meniscotheres should prove to have any special relationship to either or both of these groups, this would cast considerable light on the origin of the orders of mammals and would also have a bearing on some fundamental geological problems involving the history and nature of the continents. In any case, the early appearance of *Meniscotherium* and the unique combination in it of some very primitive and some very precocious characters involve several important aspects of general evolutionary theory.

Thus, the detailed study of this one genus is likely to have broad ramifications in biology and in geology, and it seems extraordinary that no one has seriously undertaken such a study during the 74 years that the genus has been known. Although, as noted above, some fairly good specimens have been in museum collections all this time, and although many paleontologists have referred to *Meniscotherium* or speculated about it, there has not even been an adequate published account of the available materials. We are now in a position to supply this need, and we hope to do so.

The more general program, to which *Meniscotherium* and *Coelophysis,* for all their individual importance, are merely incidental, involves intensive and thorough investigation of the geology and paleontology of the early Tertiary and of the Triassic in the Southwest. Concentration on this area and these ages was decided on because of the evidently crucial character of the data and problems involved and the inadequacy of current knowledge of them, as suggested in the preceding account. The American Museum's current campaign here began with field work under Colbert in Arizona and under me in New Mexico in 1946 and was continued by the work in 1947 here summarized. It will continue, in field and laboratory, for several years. This plan is integrated, in a still broader way, with numerous other current studies of the history of the earth and of its life—for instance, with work by Camp, Welles, and others for the University of California on the Triassic of Arizona; with that by Patterson (Chicago Natural History Museum) on the early Tertiary of Colorado, by Jepsen (Princeton University) on the early Tertiary of Wyoming, and by Gazin (National Museum) on the early Tertiary of Utah; with work by Schaeffer (American Museum) on Triassic and, with Dunkle (National Museum), on early Tertiary fishes; with a large cooperative program of work on marine fossils of the Southwest by Newell (American Museum) and others; and with my own work on the early Tertiary of South America.

Association Affairs

Itinerary, First Annual International Photography-in-Science Salon

Following the exhibition of these pictures at the AAAS Meeting in Chicago in December, they were displayed at the Buhl Planetarium and Institute of Popular Science, Pittsburgh, Pennsylvania (January 10–24) and are now at the Cranbrook Institute of Science, Bloomfield Hills, Michigan (February 2–28). They will continue to be exhibited as follows:

Cleveland Health Museum, Cleveland, Ohio	March 8–29
Science Illustrated, New York City	April 6–16
Brown University and Providence Engineering Society, Providence, Rhode Island	April 22–May 6
Gamma Sigma Epsilon, University of Florida, Gainesville	May 13–June 1
The John Crerar Library, Chicago, Illinois	June 8–21
Auburn Camera Club, Bureau of Animal Industry, USDA, Auburn, Alabama	June 28–July 12
American Osteopathic Association Annual Convention, Boston, Massachusetts	July 19–23

This photographic contest, sponsored by *The Scientific Monthly* and the Smithsonian Institution, will be held again this year. Reservations for showing the 1948 Salon pictures may be made now by writing to *The Scientific Monthly.* No dates are available prior to February 1949. The 1947 Salon pictures will also be available after July 30 of this year.

Section on Psychology (I)

Members of the psychological profession give greater support to the September meeting of the American Psychological Association in terms of attendance, offering of papers, and transaction of official business. Consequently, Section I of the AAAS always has a modest program. This year the program involved three sessions, on December 29 and 30, for the presentation of papers. About 100 members were in attendance. The session devoted to *Learning,* over which Kenneth W. Spence, of the University of Iowa, presided, included 5 papers deal-