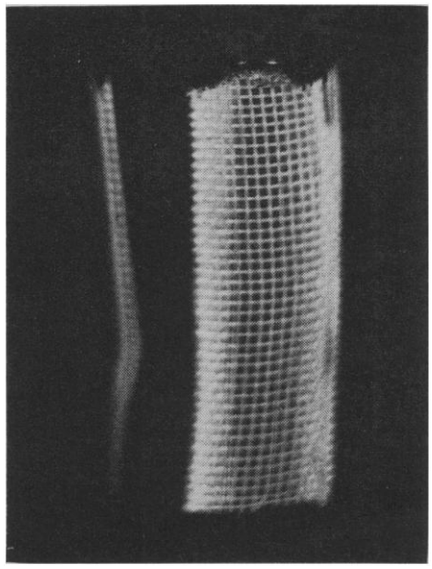

Fig. 1. Electrochemically generated luminescence; emission from the electrode is the only source of light (60 seconds; *f*, 4.5; Royal-X-pan film). The solution was $10^{-3}M$ rubrene in dimethylformamide with $0.01M$ tetraethylammonium bromide as supporting electrolyte. Concentric electrodes with nitrogen continuously bubbling through the solution. The clear definition of the electrode grids when viewed head-on, and the diffuse glow at the sides indicate that the glow occurs in solution near the inside electrode surface.

and normal fluorescence indicates that the lowest excited singlet state of the aromatic hydrocarbon is the emitting species. Because chemiluminescence was observed with both perchlorate and bromide as supporting electrolytes, anodically produced bromine does not participate in the light-producing reaction. Also, allowing a dilute bromine solution to flow over the cathode during electrolysis produced no emission. Because of the delayed response encountered in the current-reversal experiments and the observation of streams of luminescence in stirred solutions, chemiluminescence is not produced by a reaction at the electrode surface. In stirred solutions, emission was observed only in the vicinity of the cathode, and this indicates that the more stable of the two species is generated at the anode. This observation may be correlated with the emission observed at the electrode when the current was reversed from plus to minus—although sometimes a weaker emission could be seen at the other electrode, particularly in the case of chrysene. Also, in the current-reversal experiments, if the circuit was broken while chemiluminescence was being emitted, the emission dropped off quickly, but was resumed at a reduced intensity upon connecting the circuit again. This process could be repeated several times, the emission becoming less intense each time, until finally no emission was observed upon connecting the circuit. Oxygen showed a pronounced quenching effect on the emission, indicating the participation of free radicals, since all of the hydrocarbons studied are fluorescent in air-saturated solutions at room temperature. Water had no effect on the emission, a result that was surprising but consistent with observations on the electrochemical behavior of the biphenyl negative radical ion (*4*).

One is tempted to interpret the chemiluminescence as arising from the reaction of hydrocarbon radical ions ($Ar^+$ and $Ar^-$) to produce an excited singlet state ($Ar^*$):

$$Ar^+ + Ar^- \rightarrow Ar^* + Ar \qquad (1)$$

which then emits its characteristic fluorescence. However, this interpretation is not consistent with all the data presented. Because emission in stirred solutions occurs mainly in the vicinity of the cathode and because the positive aromatic hydrocarbon ions are less stable under the conditions of the experiments than the negative radical ions (*6*), it seems unlikely that $Ar^+$ would be transported from the anode to the cathode while the more stable $Ar^-$ is not transported from the cathode to the anode.

The species produced at the cathode seems to be $Ar^-$ as judged by colors observed with the naked eye at the cathode when electrolyses were performed in room light. This would suggest the possibility of oxidation of $Ar^-$ by an anodically generated species to produce chemiluminescence. Energy considerations argue against such a mechanism because, to produce an excited singlet state of the hydrocarbon by oxidation of $Ar^-$, one must remove an electron from a $\pi$-bonding orbital while leaving an electron in a higher-energy $\pi$-antibonding orbital. This also leaves the nature of the species produced at the anode in question, because the experiments described indicate that luminescence cannot be produced by oxidation of $Ar^-$ by molecular bromine. The possibility of having a complexed bromine radical (such as $Br_2^-$) react with $Ar^-$ is unlikely because chemiluminescence is observed in perchlorate media.

One possible way out of the dilemma is to postulate production of a complexed aromatic positive radical ion (such as $Ar_2^+$) at the anode which is stable enough to be transported to the cathode. Although no such species has been reported, $Ar^+$ is a good electron acceptor and aromatic hydrocarbons are good electron donors, forming molecular complexes readily. This idea receives some support from the fact that molecular complex formation has been reported with the tropylium ion (*7*) and the pyrylium ion (*8*) as acceptors, and that the concentration of hydrocarbon in these studies ($10^{-3}M$) is in the range where complex formation is known to occur.

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1 July 1964

## Late Eocene Multituberculates and Other Mammals from Wyoming

Abstract. *Isolated teeth of multituberculates have been found in association with late Eocene fossil mammals. Previous studies reported that multituberculates were not found in deposits younger than early Eocene age (Gray-bull provincial substage or equivalents). This newly found occurrence indicates that these animals are more likely to be late Eocene in age than reworked early Eocene materials.*

Joint field parties of Carnegie Museum and the University of Colorado Museum have been collecting fossil vertebrates from upper Eocene deposits (Tepee Trail formation, Hendry Ranch member) of the Badwater area, Natrona County, Wyoming (*1*, *2*). In the course of collecting small fossils by washing techniques, remains of a multi-

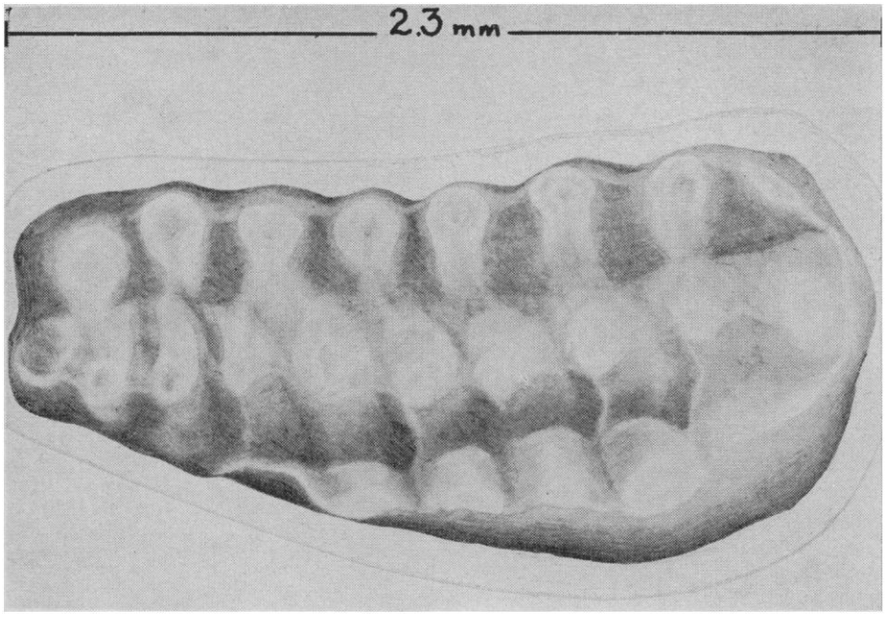


Fig. 1. First upper molar of a multituberculate, *Ectypodus* sp., from the Hendry Ranch member, Tepee Trail formation, Natrona County, Wyoming.

tuberculate, a member of a group considered to be extinct at the end of earliest Eocene time, have been found. This animal is an undescribed species related to *Ectypodus hazeni (3; 4,* Fig. 1).

Most of the fossils obtained by our parties from the upper Eocene of the Badwater area are isolated teeth of small mammals; other small mammal bones and some reptile bones occur as well. One of the peculiarities of the deposit—primarily locality 5 of Tourtelot (*1*)—is the rarity of jaw and maxillary fragments containing more than one tooth. However, the faunal sample of small mammals is remarkable for its diversity, for its content of families previously found in Oligocene or younger rocks, and for its inclusion of a few groups thought to have become extinct in the early or middle Eocene.

Larger fossil mammals that occur in the area indicate a late Eocene age for the Hendry Ranch member of the Tepee Trail formation (*2*). Some of the smaller animals have been previously recorded from upper Eocene rocks (for example, *Chumashius, Leptotomus, Microparamys, Mytonolaqus*), but the collection of some twenty undescribed species points out how little is known about the late Eocene microfaunas of North America. Additions to the fauna from the Badwater area are included at the end of this report.

Multituberculate specimens which comprise a small percentage of the fauna, certainly less than 1 percent (*5*), consist of generally well-preserved premolars and molars, exhibiting a type of preservation identical to that of similarly sized teeth of other mammals in the microfauna. Distribution and preservation of the fossils indicate that the animals represented were washed in from some other place but not from any great distance. The Badwater area (*6*) is a graben with many minor fault blocks present in the main fault block. Although it is possible, if not probable, that lower Eocene rocks occur in one or more of the minor structures, and that these rocks contain multituberculates, we have not found multituberculates, in the Hendry Ranch beds, at localities other than those containing a late Eocene fauna. The lack of genera, generally considered to be of early Eocene age, indicates that the multituberculates were probably coeval with the other mammals and not derived from the erosion of lower Eocene rocks. If they had been so derived, certainly such common early Eocene genera of small mammals as *Haplomylus, Pelycodus,* and *Tetonius* would be included in the faunal sample. These genera are often commoner than multituberculates where they occur together (*4*), and depositional agencies would favor collection of more abundant materials. The percentage of the multituberculates in the Badwater fauna may not be significantly different from that in Wasatchian deposits (*4*) and is possibly a natural percentage. In the list of the previously unrecorded mammalian families and genera of the Hendry Ranch member, Tepee Trail formation, localities 5, 5A, and 5B (this paper, *6, 7*) which follows, minus (—) indicates extension of geologic range downwards, and plus (+) indicates extension of geologic range upwards.

Multituberculata
  Ptilodontidae
    *Ectypodus* +
Marsupialia
  Didelphidae
    *Nanodelphys* —
Insectivora
  Leptictidae, 1 sp.
  Pantolestidae
  Apatemyidae
    *Apatemys*
  Nyctitheriidae
    *Nyctitherium* +
    *Micropternodus* —
  Erinaceidae
    *Geolabis*
    *?Scenopagus* +
    *?Entomolestes* +
    *Ankylodon* —
  Soricidae
    *?Domnina* —
  ?Talpidae —
  Apternodontidae
    *?Apternodus* —
    *?Oligoryctes* —
Chiroptera
Dermoptera
  ?Plagiomenidae +, 1 sp.
Primates
  Omomyidae
    *Chumashius*
    *Macrotarsius* —
  Anaptomorphidae
    ?Uintasorex +
  ?Phenacolemuridae +
Lagormorpha
  Family incertae sedis, 1 sp.
Rodentia
  Paramyidae
    *Ischyrotomus*
    *Microparamys*
Cylindrodontidae, 1 sp.
Sciuravidae
  *Sciuravus*
Carnivora
Miacidae
  *?Oodectes* +

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16 March 1964

## Radiocarbon Dating of a Late Paleolithic Culture from Egypt

Abstract. *Two radiocarbon dates of about 12,000 B.C. for a new prehistoric culture from a stratified site at Kom Ombo, Upper Egypt, throw light on a deposition phase of the late Pleistocene Nile. The dates reveal that the associated blade industry is coeval with at least the later part of the Upper Paleolithic in Europe and Southwestern Asia.*

Evidence for the existence of Paleolithic man in Egypt has been known for almost a century, and during that time large numbers of surface collections of artifacts have been made and a relatively small number of sites excavated. To my knowledge, however, no radiocarbon date for a Paleolithic culture has yet been published, although some dates have been obtained from Dynastic, Predynastic, and Neolithic materials (*1*). This lack is all the more marked when contrasted with the situation in other parts of North Africa (particularly Libya) and in southwestern Asia where a number of Paleolithic dates have been obtained in the past decade. It reflects not only the infrequency of sealed sites such as caves or rock-shelters but also the near cessation of prehistoric research in Egypt since the second World War.

It seems worthwhile, therefore, to record two radiocarbon dates recently received in connection with a newly discovered culture of the late Paleolithic in Upper Egypt. During 1962 to 1963 the National Museum of Canada sponsored a prehistoric archeological expedition to Egypt to take part in the current international Aswan Reservoir salvage program. The University of Toronto also collaborated in this research, and I served as director of the expedition. Since a large area of desert was being reclaimed at Kom Ombo, about 45 km north of Aswan, in order to resettle the larger part of the population being displaced from Egyptian Nubia by the rising waters behind the new High Dam, the Canadian expedition concentrated its efforts here where late Paleolithic sites had been reported many years ago. (*2*).

A large number of sites was found in and on the silts deposited by the late Pleistocene Nile, and a series of late Paleolithic cultures not hitherto reported from the Nile Valley was identified. One of these was recovered from a stratified occupation site buried in the silts about 3 km east of the present Nile near Gebel Silsilah. Accompanying large quantities of faunal remains were flint artifacts characterized mainly by retouched blades and bladelets and by occasional burins and scrapers. The nuclei are usually long and prismatic with plain oblique striking platforms. No geometric microliths or microburins were found in this industry, and there was no evidence of pottery, polished stone, or food production. The name *Sebekian* (after Sebek, one of the patron deities of Kom Ombo in Pharaonic times) has been given to this new culture, for which a full report is being prepared.

From two specimens of charcoal recovered near hearth areas in two separate parts of the site the following ages have been calculated (*3*):

| | |
|---|---|
| I-1291 | 14,240 ± 370 ago (12,290 B.C.) |
| I-1292 | 14,100 ± 450 ago (12,150 B.C.) |

These ages are not only highly consistent with each other but also agree well with local geological evidence. The results of further samples now being run from this and other sites at Kom Ombo will shortly be made available. It is hoped that studies now under way on the faunal materials, soils, and possible paleobotanical remains from these sites will help document the climate and ecology of this part of the Nile Valley during this phase of human occupation. The aforementioned dates not only show that the Sebekian culture was coeval with Upper Paleolithic cultures in such regions as Western Europe (for example the Middle Magdalenian) and southwestern Asia; they also provide relative ages for several other different lithic industries with which the Sebekian is in stratigraphic relationship at Kom Ombo. In addition, we now have a geologically useful absolute dating for the period when the late Pleistocene Nile was still depositing silts in what is now desert before it shrank into its modern narrow floodplain during Holocene times. This should supplement the data on Nile geological history recently presented by Fairbridge (*4*) and other data which may be expected soon from current investigations in Egyptian and Sudanese Nubia (*5*).

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1 June 1964

## Purified Interferons: Physical Properties and Species Specificity

Abstract. *The antiviral activity of highly purified preparations of chick and mouse interferons has marked species specificity. This species specificity is not explained by a demonstrable difference in adsorption rates. There is no difference in charge between the molecules as measured by combined zone electrophoresis or ion-exchange chromatography. The interferons are distinguishable by thermal inactivation studies and by precise chromatography on G-100 Sephadex columns. With the latter method, interferons produced by the same cell species (i) in vivo or in vitro, or (ii) in response to different viruses, have been shown to be identical. The same virus stimulates physically distinguishable molecules in the two different cell species. These findings indicate that interferon is a virus-induced product of the host genome.*

The molecular weight and charge of chick interferon have been disputed recently (*1–4*). Crude interferons have been prepared by others (*5*) in which the antiviral activity measured in heterologous assays varied from 1 to 10 percent of the homologous antiviral effect. No precise physicochemical