Only one specimen eviscerated while being collected—the one noted as having viscera on 26 October 1959. Unfortunately, because of bad weather and unfavorable tidal conditions throughout the daylight hours, it was impossible to make the collections planned for near the beginnings of December and January. However, findings based on groups of specimens (indicated in Table 1 by ‡) dredged from deeper water within a few miles of this locality agree with what would have been expected. Thus it appears that *Parastichopus californicus* probably undergoes regular evisceration in the month of October and that within 1 to 3 months thereafter regeneration has proceeded sufficiently for the intestine to be functional as indicated by its being full of mud.

These findings are in close agreement with what Bertolini (*1*) found for *Stichopus regalis* and in contrast with Dawbin's (*3*) finding that in *S. mollis* evisceration appears to be a rare process. No experimental studies have been undertaken to determine rates or morphological details of regeneration, but the studies of Bertolini (*4*), Dawbin (*5*), Kille (*6*), and Mosher (*7*) suggest that such studies might yield interesting comparative data.

EMERY F. SWAN
Department of Zoology, University of New Hampshire, Durham

References and Notes

1. F. Bertolini, *Atti accad. nazl. Lincei Rend. Classe sci. fis. mat. e nat.* **15**, 893 (1932).
2. This work was carried out while I was on leave for academic improvement from the University of New Hampshire and was supported by the National Science Foundation (grant No. G-4959).
3. W. Dawbin, *Trans. Proc. Roy. Soc. New Zealand* **77**, 497 (1949).
4. F. Bertolini, *Pubbl. staz. zool. Napoli* **12**, 432 (1933).
5. W. Dawbin, *Trans. Proc. Roy. Soc. New Zealand* **77**, 524 (1949).
6. F. Kille, *Biol. Bull.* **69**, 82 (1935).
7. C. Mosher, *Zoologica* **41**, 17 (1956).

30 December 1960

Radioactive Dating of Tertiary Plant-Bearing Deposits

Abstract. Four potassium-argon determinations from Tertiary rocks in the interior of British Columbia have yielded dates ranging from 45 to 49 million years. This suggests contemporaneity of three separate localities within the Middle Eocene epoch. Abundant plant micro- and macrofossils support this conclusion and indicate a flora quite different from floras of comparable age in western United States.

A more complete understanding of the Cenozoic history of the southern interior of British Columbia has long been hampered by the lack of a satisfactory local time scale, whereby isolated occurrences of Tertiary sediments and volcanics could be correlated with one another and with better-dated rocks of the western United States. Fossil plants, insects, fish, and mollusks have been collected at various localities, but they have provided no clear-cut evidence of age for any one series of rocks. The application of fossils to the dating of these rocks has been complicated by differences in latitude and environment from relatively well-dated collections to the south. Lithologic and stratigraphic correlations of volcanic rocks have led to confusion, and some successions originally correlated with Cenozoic strata have later been shown to be Cretaceous on paleontological evidence. Geomorphic evidence of age is generally lacking and, even where present, has often been ignored or misinterpreted.

Table 1. A summary of localities, previous age determinations, source of samples, and potassium-argon (K-Ar) datings of Tertiary rocks from southern British Columbia. Constants: $\lambda_e = 0.589 \times 10^{-10}$ yr.; $\lambda_\beta = 4.76 \times 10^{-10}$ yr.; $K^{40}/K = 0.0118$ atomic percent.

Locality	Previous datings on fossil evidence	Source of biotite	K-Ar datings (10^6 yr)
Princeton (120½°W, 49½°N)	Late Eocene-Early Oligocene (*5*), Late Oligocene-Early Miocene (*5*), Oligocene or Miocene (*5*), Eocene (*2*, *5*), Oligocene (*5*)	Volcanic ash	48
Tranquille (120½°W, 50¾°N)	Late Miocene (*5*), Miocene (*5*), Oligocene or Lower Miocene (*5*)	Diabase flow or sill	49
Savona Mountain (120¾°W, 50¾°N)	Datings same as for Tranquille	Trachyte flow	45
Rock Creek	Eocene (*3*), Upper Eocene–Oligocene (*4*)	Volcanic ash	49

The development of the potassium-argon technique for dating has provided a new and useful tool for assisting in untangling the confused data and for the establishment of a stratigraphic column which is independent of the fossil record. Accordingly, we have embarked on a program for absolute dating through the collection of potassium-bearing rocks, with the ultimate objective of providing several well-dated horizons in the Tertiary sequence to which future paleobotanical, petrologic, tectonic, and geomorphic evidence can be related.

To date, four age determinations from biotite-bearing rocks are considered most significant because of their intimate relationships to fossil-bearing strata (Table 1).

A potassium-argon date of 48 million years for the Princeton ash places it, according to recently proposed time scales (*1*), about the middle of the Eocene. This age accords well with that indicated by two sets of mammal teeth from a coal bed situated 100 feet above the ash bed. These teeth were identified by Russell and by Gazin (*2*) as remains of Middle Eocene trogosine tillodonts. This group of tillodonts is only known to range from uppermost Lower Eocene to upper Middle Eocene, and the Princeton form is known only from Middle Eocene. The mutual agreement of isotope and fossil dates enhances the validity of both and clearly indicates that the age of at least this part of the Princeton succession is Middle Eocene.

In addition to providing an absolute datum from which to work, the present findings agree with the conclusions previously reached by one of us (G.E.R.) from a preliminary study of plant macro- and microfossils—namely, that the Princeton and Tranquille sediments contain synchronous floras. Similarly, evidence provided by an earlier report (*3*) on a florule near Rock Creek suggests that it also is synchronous with the Princeton and Tranquille floras.

The main difficulty in dating the floras from the Princeton, Tranquille, and other locales appears to result from the effects of quite different ecologic, physiographic, and latitudinal conditions from those which accompanied the development of well-dated Eocene floras in the southern and western United States. The Princeton and Tranquille sediments contain a preponderance of *Equisetum, Azolla, Metasequoia, Sequoia, Chamaecyparis, Pinus, Alnus, Corylus*, and *Juglans*, together with many other species of temperate association. This is in contrast to the generally subtropical to warm-temperate aspects of Eocene floras of the Gulf Coast and western United States. It seems apparent that there was a more dramatic change in the whole floral assemblage from southerly into more northerly latitudes during Middle Eocene times than has hitherto been suspected. This, in turn, would explain adequately the widely diversified datings which have been given by various paleontological investigators (*3–5*).

The Princeton and Tranquille floras appear to be most closely related to a florule reported from Republic, Washington, by Brown (*6*). This florule was considered to be older than the mid-Miocene Latah flora from Spokane; it was provisionally dated by Brown as early Miocene. Arnold (*7*), however, refers to the Republic florule as Oligocene. The present evidence would suggest that the Republic florule is Eocene in age.

In terms of age, the Princeton and Tranquille floras are synchronous with that from the Green River formation of Wyoming and Colorado. However, there appears to be a fairly large discrepancy in the floral composition between the two. This is not surprising, inasmuch as there are some 4½° of latitude between the two, together with unknown ecological and physiographical differences. The discrepancies in floras point out the continuing need for fundamental research on the extent of the effect which latitude, altitude, mountain barriers, climate, and other factors had on synchronous but geographically isolated floras of the Tertiary.

It is intended that the present program of potassium-argon dating should provide the basis for relating future paleontological and stratigraphical investigations. With several critical horizons now well established, it will be much easier to relegate more accurately many other sedimentary and volcanic series to the stratigraphic column. This, in turn, will greatly enhance our knowledge of the history of the Tertiary period in western North America (*8*).

GLENN E. ROUSE

Departments of Biology and Botany and *Geology, University of British Columbia, Vancouver*

W. H. MATHEWS

Department of Geology, University of British Columbia

References and Notes

1. J. L. Kulp, *Rept. 21st Intern. Geol. Congr.* (1960), pt. 3, pp. 18–27; J. F. Everden *et al.*, *Bull. Geol. Soc. Am.* **69**, 1689 (1960); A. Holmes, *Trans. Edinburgh Geol. Soc.* **17**, 183 (1960).
2. L. S. Russell, *Am. J. Sci.* **29**, 54 (1935); C. L. Gazin, *Smithsonian Inst. Publs. Misc. Collections* 121, No. 10 (1953).
3. D. P. Penhallow, *Trans. Roy. Soc. Can. IV* **13** (1907).
4. R. A. Daly, *Mem. Geol. Survey Can. No. 38* (1912), pts. 1–3.
5. J. W. Dawson, *Trans. Roy. Soc. Can. IV* **8** (1890); G. M. Dawson, *Geol. Survey Can.* **7** (1894), pt. B; E. W. Berry, *Can. Dept. Mines, Geol. Survey, Bull. No. 42, Geol. Ser. No. 45* (1926); W. A. Bell, in H. M. A. Rice, *Mem. Geol. Survey Can. No 243* (1947); ———, in W. E. Cockfield, *ibid., No. 249* (1948); L. S. Russell, "Annual Report for National Museum for 1955–56," *Bull. Can. Dept. Northern Affairs No. 147*, p. 84; W. L. Fry, in H. M. A. Rice, *Bull. Geol. Survey Can. No. 55* (1959).
6. R. W. Brown, *U.S. Geol. Survey, Prof. Paper No. 186-J* (1937).
7. C. A. Arnold, *Univ. Michigan, Contribs. Museum Paleontol.* **12**, 245 (1955).
8. This investigation was supported by an operating grant from the National Research Council of Canada, for which grateful acknowledgement is extended. Potassium-argon analyses were made by H. Baadsgaard and A. Stelmach, and their associates at the department of geology, University of Alberta. We thank them for their careful efforts and close cooperation. To L. S. Russell, National Museum of Canada, we also offer our appreciation for suggestions most useful in preparing this report.

14 November 1960

Effect of Electroconvulsive Shock on an Extinguished "Fear" Response

Abstract. To test Gellhorn's hypothesis that electroconvulsive shock reinstates extinguished responses, a conditioned "anxiety" response was established and then extinguished in rats. A series of treatments did not restore the extinguished "anxiety" response; in fact, control animals showed appreciable spontaneous recovery of the "anxiety" response while treated animals did not.

Studies reported by Gellhorn (*1*), and a later investigation by Hamilton and Patton (*2*), have shown that convulsions produced variously by Metrazol, insulin, or electroshock would reinstate previously inhibited (extinguished) conditioned responses. In these studies animals were trained to avoid shock by jumping from one compartment to another of a double grill box upon presentation of an auditory stimulus. The avoidance response, which was extinguished by means of a series of nonshock trials, reappeared after convulsive therapy.

Griffiths (*3*) later replicated this finding by using treadmill running to induce convulsive seizures. On the assumptions that the avoidance behavior in these studies was motivated by "fear" and that the effect of withholding the shock following acquisition was to extinguish a conditioned "fear" response, Griffiths inferred from his results that convulsions tend to reinstate the extinguished "fear."

The present study was intended as a test of this inference by a technique which was first described by Estes and Skinner (*4*). In this situation thirsty animals are trained to press a lever for a water reward; the fear response is then superimposed on the lever-pressing responding by pairing an auditory stimulus with a shock during the lever-pressing session. The "fear" response appears as a perturbation in the lever-pressing curve, accompanied by crouching, immobility, and usually defecation.

Twelve male albino rats, 60 days old at the start of the experiment, served as subjects. All animals were deprived of water for 48 hours. They were then placed in modified Skinner boxes in which they learned to press a lever, first for regular, and then for aperiodic, water reward. All sessions were of 8-hour duration and were run on alternate days. Animals received no water except that obtained in the experimental boxes.

The "fear" response or conditioned emotional response was superimposed on the lever-pressing habit as follows. While the animals were lever-pressing, a clicking stimulus was presented for 3 minutes and terminated contiguously with the delivery of a painful electric shock (1.5 ma) to the animals' feet. All animals received such conditioning trials every 20 minutes through the 8-hour session. Not all of these trials, however, were shock-reinforced during the 8-hour session. Only 50 percent of the conditioned stimuli were paired with the shock, in a mixed order.

The conditioned emotional or "fear" response, characterized by suppression of lever-pressing, piloerection, urination, and defecation was quantified in the following manner. A record was kept of the number of lever responses made by the animal in the 3-minute clicker period and the 3-minute period preceding the clicker. The magnitude of the "anxiety" response was measured in terms of a suppression ratio which was computed by dividing the number of responses made during the 3-minute clicker period by the number of responses made during the 3-minute period just preceding the clicker onset. Complete cessation of lever responding during the 3-minute clicker period yields a ratio of 0 and is taken to indicate a well-developed "fear" response. Unchanged output during the clicker yields a ratio of 1.00 and increased output a value greater than 1.00. Mean suppression ratio values were calculated for each 8-hour session for each animal. Animals received such conditioning trials for 23 successive days at which time all showed marked suppression of lever responding during the stimulus period.

The extinction procedure was the same as that during conditioning except that the shock was omitted. This procedure was maintained for seven successive days until the suppression ratio values for all animals approximated a value above .90.

Animals were then divided into experimental (six animals) and control (six animals) groups. The experimental animals were given 21 electroconvulsive shock treatments administered three per

Table 1. Suppression ratio values for the last conditioning session (I), the last extinction session (II), and the first trial of the recovery test after electroconvulsive shock (III).

Rat No.	I	II	III
	Treated group		
AD 1	0.37	0.98	0.49
AD 5	.08	.84	1.00
AD 6	.16	.92	0.82
AD 10	.06	.91	.80
Mean	.17	.91	.78
	Control group		
AD 4	0.15	0.72	0.06
AD 7	.37	.87	.00
AD 8	.12	.97	.00
AD 9	.06	.99	.02
AD 11	.05	.93	.04
Mean	.15	.90	.02