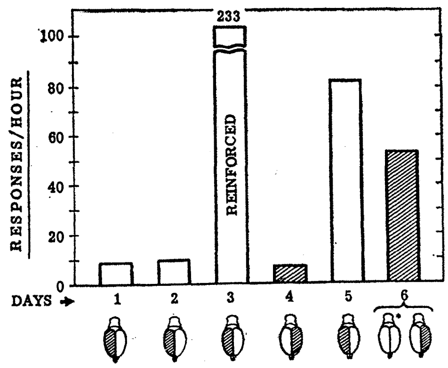

Fig. 2. Transfer of the learning engram to the untrained hemisphere. Days 1 and 2 give operant level, and day 3 shows the amount of responding made during training. The following days give the results of extinction tests. On day 4 the trained cortex is depressed, and day 5 shows the difference when the trained side is functional. On day 6 the animal was permitted to make one reinforced response with both hemispheres functional, and then 1 hour later the extinction test was given with the trained hemisphere depressed. The greater amount of responding indicates transfer has occurred after this single response.

of the kind of learning that can be established, and furthermore the presence or absence of a learning engram may be tested repeatedly over a number of days.

After recovering from spreading depression, the animal does not spontaneously transfer the engram to the other side, a point also noted by Bureš. Our testing procedure extended over a week or two, and, despite this prolonged period, transfer still did not occur. If, however, an animal with a unilateral engram was allowed to make one response and receive one reinforcement while both cortical hemispheres were functional, transfer of the engram to the previously untrained side occurred.

An example of an animal demonstrating such one-trial transfer is shown in Fig. 2. On the first two days operant level performance was recorded with one hemisphere depressed. On the 3rd day the learning of a conditioned performance is demonstrated by the 233 reinforced responses made during 1 hour of conditioning. An extinction test was given on day 4 with the trained cortex depressed. The animal here performed at operant level indicating that no "learning" had occurred in the untrained side. On the 5th day the animal was tested in extinction with the trained cortex functional, and retention of training was shown by the animal's making 83 responses without reinforcement. This is well above operant level. The animal was permitted one reinforced response with both hemispheres functional on day 6. One hour later the animal was again tested, this time with the *trained* cortex depressed. The extinction score of 56 responses indicates that transfer to the previously untrained side occurred and that one reinforcement was adequate to produce such transfer. The degree of success in training was tempered by the poor physical condition of the animals at the end of 2 weeks of continued elicitation of spreading depression, in view of which the positive evidence of one-trial transfer is additionally convincing. So far, 12 animals have shown unilateral learning, and an additional five have shown single-trial transfer.

These results are intriguing. The engram remains restricted to one hemisphere even though the neural connections for transfer are intact, and one single performance can result in transfer. It would seem that the animal does not transfer the engram without going through the actual behavior which is involved and that the "learning" of the engram by the untrained side takes place in an all-or-none fashion. This last point is of particular interest in connection with the work of Estes (*5*) whose recent psychological investigations led him, against his previous formulations, to think that learning is an all-or-none rather than an incremental process (*6*).

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Seasonal Evisceration in the Sea Cucumber, Parastichopus californicus (Stimpson)

Many species of sea cucumbers under rough handling will discard (eviscerate) their intestinal tracts and respiratory trees. For many years investigators at the Friday Harbor Laboratories of the University of Washington have noted occasional individuals of the large aspidochirote holothurian, *Parastichopus californicus* (Stimpson), which, when examined immediately after being dredged, lacked these organs. The general assumption has been that these animals probably were stimulated to eviscerate by the mauling experienced in the dredge.

Table 1. Presence or absence of intestine and respiratory trees in *Parastichopus californicus* collected at different seasons.

Date*	No. of animals: Complete viscera	No. of animals: Incomplete viscera†
2 Sept. 1959	12	0
28 Sept.	10	2
12 Oct.	8	4
26 Oct.	1	11
11 Nov.‡	0	25
10 Dec.‡	1	7
27 Dec.‡	1	0
22 Jan. 1960‡	17	0
3 and 5 Feb.	12	0
13 Feb.‡	5	0
4 March	12	0
18 March‡	23	0

* Also on 3 April, 30 April, 2 June, 4 July, and 3 August 1960, 12 specimens were collected, and all were found to have their viscera complete. † Intestine and respiratory trees lacking or in early stages of regeneration. ‡ Groups of specimens dredged from deeper water.

Some years ago in the late fall I collected a number of these animals from shallow water with a potato hook, brought them back to the laboratory in pails, and immediately opened them. The majority lacked the viscera mentioned above. The place of their collection was too shallow for dredging, and there was no reason to suspect that they had recently been handled by man, nor was there any evisceration after they were lifted from their habitat. Thus spontaneous evisceration, or at least evisceration in nature without stimulation caused by man's activities, was suspected.

In view of Bertolini's observations (*1*) on *Stichopus regalis* at Naples, which strongly suggests a seasonal evisceration in that species in late fall, the question arose as to whether or not *Parastichopus californicus* might not have a similar habit. Therefore, when an opportunity to spend another year at the Friday Harbor Laboratories (*2*) developed, plans were made for periodic collection of this animal from shallow water. As it appeared desirable to make all collections from the same locality, and because no readily accessible shallow-water area was found where the species occurred in very large numbers, each collection had to be limited in size.

Collections of 12 specimens each were made from a rowboat from low water to about 12 feet below that level with a long-handled potato hook. These animals were taken along the shore between the observation pier (48°-32.7′N, 123°00.4′W) and a cove about ½-mile north (48°33.3′N, 123°00.3′W), known locally as Fern Cove. A summary of the findings is given in Table I.

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.

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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,