self-stimulation periods for the hypothalamic placement revealed acceleration in heart rate for six of the eight animals during self-stimulation. The remaining two animals performed in a stable manner for hypothalamic self-stimulation and showed a decrease in heart rate during the 5-minute self-stimulation periods compared to the 5-minute control periods. For septal self-stimulation these animals showed sharply contrasting results. A comparison of the 5-minute alternating control and self-stimulation periods during such septal stimulation sessions revealed a deceleration in heart rate for eight of the nine animals during self-stimulation. The ninth animal performed in a stable manner but showed an increase in heart rate. The differences in heart rate for the two kinds of self-stimulation were highly significant. A Friedman two-way analysis of variance (*3*) provided statistical confirmation ($p = .001$).

A further analysis of the data for all 17 electrodes (both in the hypothalamus and in the septal region) showed that the range of variation in heart rate was consistently lower during the 5-minute self-stimulation period than it was in the alternating 5-minute control periods. In 15 of the 17 electrode placements producing self-stimulation, variability of the cardiac rate decreased regardless of the direction of the rate change or its magnitude. Although the lever-pressing response rates were higher for hypothalamic than for the septal self-stimulation, no systematic relationship between the lever-pressing response rate and the variability in heart rate could be observed. In addition, it seems improbable that the reduction in heart-rate variability can be easily explained by changes induced by the lever-pressing behavior per se, since previous experiments (*4*) have indicated that muscular activity actually produces increases in the variability of the heart rate. Direct activation of neurohumoral mechanisms by the brain stimulation, however, could account for such effects upon the peripheral reactivity of the heart.

Histological analysis (*5*) of the hypothalamic electrode placements producing cardiac acceleration revealed involvement of the dorsomedial and ventromedial nuclei. The two hypothalamic electrode placements which produced cardiac deceleration involved the dorsal hypothalamus. One of these placements was medial to the fornix, and the second impinged upon the ventricle in the region of the lateral septal nucleus. Septal electrode placements which produced cardiac deceleration were located in the rostral and medial septal nuclei. The one septal electrode placement which produced cardiac acceleration involved the lateral septal nucleus bordering on the nucleus accumbens septi.

The effects of electrical self-stimulation of the brain on heart rate vary markedly with the location of the electrode in the brain. Our findings on the slowing of heart rate during septal self-stimulation are in substantial agreement with Malmo's results despite the difference in methods of measurement in the two experiments. On the other hand, our findings on heart-rate acceleration during hypothalamic self-stimulation make it difficult to accept general propositions which relate the rewarding effects of brain stimulation to parasympathetic quieting reactions of the autonomic nervous system; moreover, oversimplified interpretations of the role of sympathetic and parasympathetic influences on the rewarding effects of brain stimulation which are based solely on heart rate changes may be somewhat premature without more information about neurohumoral and hemodynamic factors which can affect cardiovascular function.

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Seed Discharge in Arceuthobium: A Photographic Study

Abstract. *Photographs, made at a speed of 5 microseconds, of the ejection of the* Arceuthobium *seed from its fruit, show that tumbling in the vertical plane begins soon after discharge and that most seeds have turned 90 degrees when they have traveled about 6 centimeters. As the seeds leave the fruit they have a viscous sheath around the trailing end that disintegrates after the seeds have traveled about 2 to 3 centimeters. This viscous material does not act as a rudder as has been postulated.*

The seed dispersal mechanism of the dwarfmistletoe (*Arceuthobium*) is unique and has been considered by Ridley (*1*) to be one of the most efficient in the whole plant kingdom. The general mechanics of seed expulsion are known, but specific processes and forces are far from understood (*2, 3*). Each *Arceuthobium* fruit contains a single semifusiform seed (Fig. 1). When the fruit is ripe, the pedicel is elongated and recurved so that the distal end points downward. An abscission zone develops between the tip of the pedicel and the base of the fruit. High hydrostatic pressure develops in a layer of viscin cells surrounding the seed, and when the fruit is severed from the pedicel, the exocarp of the fruit rapidly contracts and hurls the seed upward.

The greatest horizontal distance (for seed flight to a point on the same level as the point of discharge) that we have measured was 1463 cm (48.0 feet) for *Arceuthobium vaginatum* f. *cryptopodum*. Weir (*4*) recorded a flight of 66 feet from a point 8 feet above ground level for an unnamed species of *Arceuthobium.*

Hawksworth (*3*) studied the ballistics of seeds of *A. vaginatum* f. *cryptopodum*, and estimated their initial velocity to be about 1370 cm/sec and the initial acceleration to be 4.7×10^6 cm/sec^2.

In an attempt to learn more of the expulsion process, seed discharge was studied photographically. The equip-

Table 1. Vertical departure of seeds of *Arceuthobium* from original line of flight.

Flight distance (cm)	Seeds measured (No.)	Vertical angle of departure (mean and S.D.) (deg)
0.6 to 1.5	7	17 ± 17
1.6 to 2.5	63	29 ± 29
2.6 to 3.5	36	45 ± 39
3.6 to 4.5	8	63 ± 55

ment used was a 35-mm single lens reflex camera with an 85-mm lens on a 100-mm extension tube, and a pendulum device for triggering a high-speed strobe unit (*5*). A mature fruit with the pedicel end pointing into the area to be photographed was placed on the base of a pendulum 8 cm long. Seed ejection was triggered by gently heating the fruits from below (50°C was sufficient to cause seed expulsion in nearly all cases). When the seed was ejected from the fruit (Fig. 1*F*), the recoil of the exocarp, which remained on the pendulum, caused the pendulum to swing back to a contact point and trigger the strobe unit. The assembly was used in a dark room with the camera shutter open. The exposure period was thus determined by the length of the light flash.

The dwarfmistletoe used in this work was *Arceuthobium vaginatum* f. *cryptopodum*, a common parasite of *Pinus ponderosa* in the southwestern and central Rocky Mountain states. Seeds of this species average 2.9 mm in length and 1.1 mm in diameter; fruits are about 3 by 5 mm.

Initial results with flash speeds of 3 to 5 × 10^{-3} second failed to stop the rapid seed-flight action (Fig. 1*A*). This photograph shows the violent release of viscous material that is ejected behind the seed. (The seed is out of the field of view.)

Photographs at a speed of 5 × 10^{-6} second were then obtained by means of a General Electric FT-106 flashtube. This speed did not stop the action completely, but did give fairly satisfactory results (Fig. 1, *B–G*). A seed that has traveled about 2.2 cm from the fruit is shown in Fig. 1*B*. The large mass of viscous material ejected behind the seed should be noted.

The seeds are ejected with the round end forward, but their orientation soon deviates from the axis of the original line of flight (Fig. 1*G*). An analysis of the vertical degree of departure of the seeds from the original line of flight showed a progressive increase with distance from the fruit as shown in Table 1. The high standard deviations indicate great variability in the flight angles, but on the average seeds that traveled for about 3 cm deviated by 45°. If the data in this tabulation are projected, they indicate an average angle of departure of 90° by the time the seeds have traveled about 6 cm. The tumbling seems to be primarily in the vertical plane.

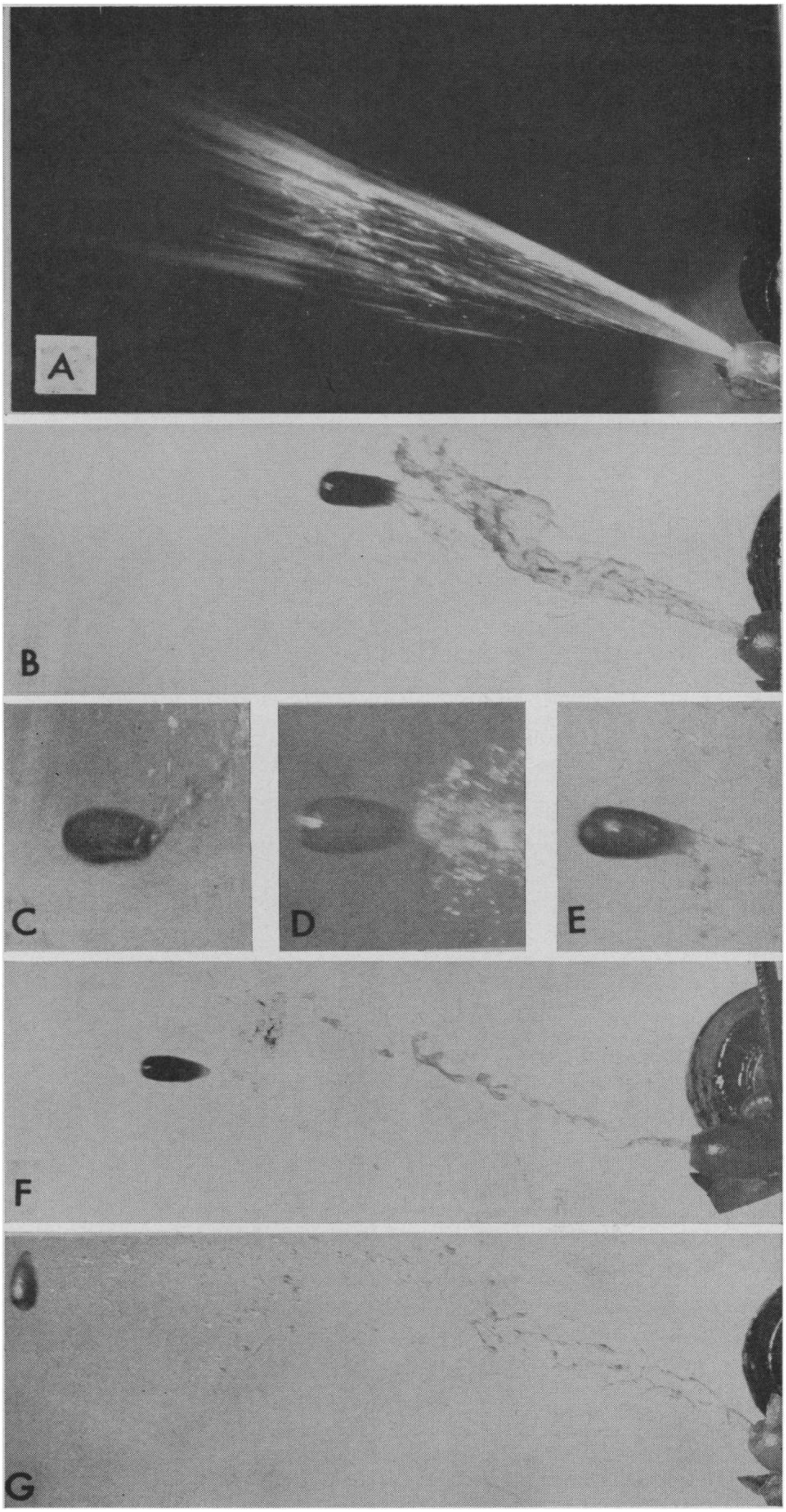

Fig. 1. Seed expulsion in *Arceuthobium*. *A*, Taken at a speed of 5 msec. Seed out of view to left, *B* to *G*, Taken at 5 μsec. *B*, Seed with viscous sheath intact. *C*, Oblique end view of seed shows sheath and indentation. *D* and *E*, Stages in the disintegration of the viscous sheath. *F* and *G*, Seeds in flight 3 to 4 cm from fruit.

The seeds have a cylindrical sheath of viscous liquid material as they are ejected from the fruit (Fig. 1, *B, C*). The squarish shape of the seed in Fig. 1*B*, in comparison with seeds that have traveled further (Fig. 1, *F, G*), deserves mention. This sheath extends as a ring slightly behind the seed causing a slight central depression at the rear of the seed (Fig. 1*C*). The sheath usually disintegrates by the time the seed has traveled about 2 to 3 cm, although some liquid material seems to fall from the seeds for about the next 2 cm of flight (Fig. 1*G*). This viscous material thus does not remain attached to the seed to form a rudder, as some workers have postulated (*6*).

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"Pliocene-Pleistocene" Boundary in Deep-Sea Sediments

Abstract. *Changes in planktonic microfossil assemblages in Atlantic sediment cores, at approximately the beginning of the Quaternary, correspond in a general way with those recognized in Pacific cores. How closely the horizon marked by these changes approximates to the Pliocene-Pleistocene boundary is not yet established.*

Recently, Ericson, Ewing, and Wollin (*1*) proposed that the Pliocene-Pleistocene boundary be defined by certain paleontological criteria in deep-sea sediments (Fig. 1, B). It is necessary to consider how well the horizon they define agrees with the onset of the climatic deterioration which is generally accepted as marking the beginning of the Pleistocene epoch, and the distinction made between "Tertiary" and "Quaternary" in earlier publications on deep-sea sediments.

Recognition of the Pliocene-Pleistocene boundary in deep-sea sediments is particularly important because Quaternary sequences on the ocean floor are commonly more complete, and more easily correlated, than those on continents. After the limits of the Pleistocene have been recognized in pelagic sediments, geologic events recorded in the cores can be dated by isotopic methods more readily than those recorded in continental deposits. In cores 20 to 30 meters long from an appropriate region such as the north Atlantic Ocean, the earliest of the sequence of layers of ice-rafted material (*2*) could be established, and this horizon could be correlated in widely separated cores by means of wide-ranging planktonic microfossils.

Ericson *et al.* recognize a faunal boundary in seven cores from the Atlantic and one from an adjacent part of the Indian Ocean, and they contend that the evolutionary changes marked by their paleontological criteria (principally, extinction of discoasters and several foraminiferal species) are profound enough to indicate that they were caused by a marked and abrupt climatic change. This interpretation is open to question. Discoasters had been decreasing in number of species, if not of individuals, for a considerable time before their extinction. Perhaps five foraminiferal species became extinct at or near the "Pliocene-Pleistocene boundary," but a much greater number survived through it. The fact that micropaleontologists have hitherto found it difficult to define a Pliocene-Pleistocene boundary is in itself an indication that, among the total faunal assemblages, these changes are not particularly striking or profound. More pronounced faunal changes have occurred at intervals through geologic time, but many of them are not clearly attributable to marked climatic change, and fewer are attributable to the onset of glacial periods (*3*). Only one of the cores discussed by Ericson *et al.* contains ice-rafted detritus, and this lithologic evidence for the onset, or at least one of the intensifications, of antarctic glaciation occurs considerably lower in the core than the "Pliocene-Pleistocene" boundary they define paleontologically.

Thus the relation between the boundary defined by Ericson *et al.* and the generally accepted Pliocene-Pleistocene boundary remains uncertain. We next consider how their boundary relates to that previously used to distinguish tentatively between "late Tertiary" and "Quaternary" in Pacific sediments.

In two tropical Pacific cores, Arrhenius (*4*) based a distinction between Pliocene and Pleistocene on geochemical evidence—principally, changes in the rate of accumulation of calcium carbonate. Such changes in sedimentary characters are geographically restricted, and could be used to distinguish this horizon in only a portion of the tropical Pacific Ocean. However, to the extent that they are caused by significant changes in atmospheric circulation, it may be possible to correlate them with climate-dependent sedimentary characters in other regions.

Bramlette and Riedel (*5*) pointed out that discoasters, abundant throughout the Tertiary, are practically absent in Recent sediments. Bramlette (*6*) correlated a tentative "Tertiary-Quaternary" boundary in the aforementioned tropical Pacific cores described by Arrhenius, largely on the basis of the abrupt disappearance of discoasters, and partly on other changes in the calcareous nannoplankton.

Riedel (*7*), investigating radiolarians in tropical Pacific cores, found that two (*Pterocanium prismatium* and *Eucyrtidium elongatum peregrinum*) became extinct approximately simultaneously, at a horizon approximately correlated with that believed to represent the end of the Pliocene in Arrhenius' paper. Therefore the upper limit of common occurrence of these two radiolarians was tentatively interpreted as indicating the "top of the Pliocene".

For some years these changes in discoasters (and other calcareous nannoplankton) and radiolarians were used to distinguish a boundary tentatively interpreted as separating "late Tertiary" from "Quaternary" in Pacific sediments (*8, 9*).

To determine whether these changes in nannoplankton could be recognized in a well-established Italian Pliocene-Pleistocene sequence, and whether they coincided with the onset of glacial conditions, Bramlette examined samples, made available by Emiliani and Selli (*10*), from the section at Le Castella (Calabria). However, the calcareous nannoplankton assemblages proved to be sparse, and reworking of older forms into younger deposits