back and forth, through, and around the recording site, which suggests some kind of "reverberation," although the exact geometric pattern of the pathway and its dimensions could not be determined at this stage of the investigation.

3) Since the distance between the tips of the microelectrodes is known, the velocity of propagation can be estimated by measuring the time that the "wavefront" takes to travel from one tip to the other. It has been found in these experiments that the order of magnitude of the velocity of propagation is 0.5 to 5 mm/sec.

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3. Aided by grant B-649, National Institute of Neurological Diseases and Blindness, U.S. Public Health Service.
4. It is a pleasure to acknowledge the assistance of Cora Rucker, department of anatomy, University of California, Los Angeles, in the preparation of the anatomical material.
5. *Spindle-bursts* is a term used in electroencephalography to designate the wave-trains of progressively increasing and decreasing amplitudes that characterize the appearance of the "synchronized" state.

4 June 1956

Selective Action of Pentobarbital on Component Behaviors of a Reinforcement Schedule

Dews (*1*) has shown that the effects of sodium pentobarbital on a learned response in pigeons depend critically on the schedule of reinforcement used to maintain the response. Behavior under a fixed-interval reinforcement schedule (that is, after a fixed period of time, the first occurrence of some arbitrarily selected response makes food accessible to the subject for a brief period) shows great sensitivity to sodium pentobarbital. Different subanesthetic dosages produce a variety of changes, including both a depressive and an excitatory effect. On the other hand, behavior under a fixed-ratio reinforcement schedule (that is, food is presented after every *n*th occurrence of the response) is resistant to the drug. With this schedule of reinforcement, dosages approaching the anesthetic level are required to produce any change in the rate of emission of the response under observation.

The differential reaction of differently maintained behavior to sodium pentobarbital is here further investigated (*2*).

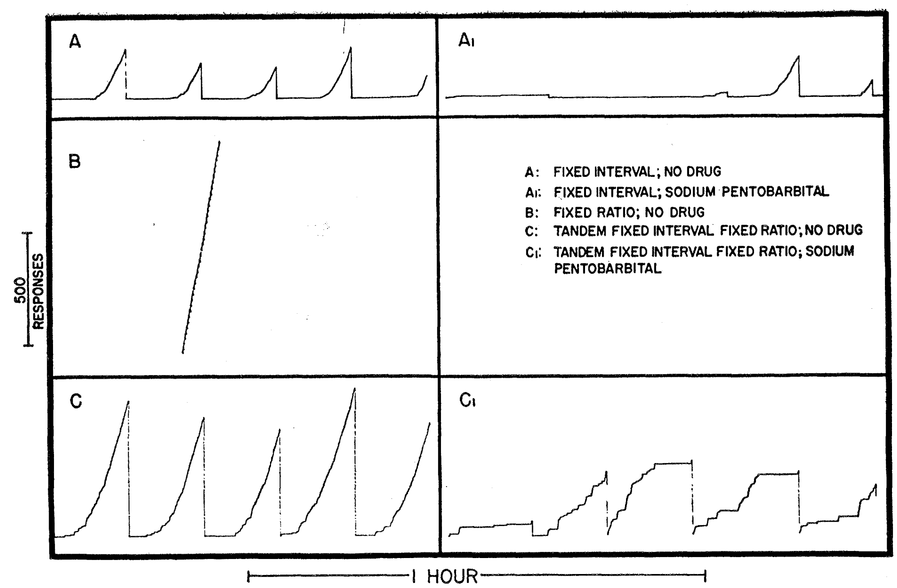

Fig. 1. Cumulative response curves showing the effects of sodium pentobarbital on behavior maintained by fixed-interval and tandem schedules of reinforcement.

Two food-deprived pigeons were used, and the response was pecking an illuminated disk. The reinforcement was brief access to food. The experimental apparatus has been described by Ferster (*3*).

The schedule of reinforcement used in this experiment is one that combines certain features of both fixed-interval and fixed-ratio schedules. The pigeon is reinforced after 10 min, but for the 13th response after 10 min, instead of the 1st response after 10 min (as in an ordinary 10-min fixed interval). This schedule is designated as a *tandem*: fixed interval of 10 min, fixed ratio of 12 responses (*4*).

The behavior resulting from the tandem schedule is similar to behavior under fixed-interval reinforcement, in that the animal's response rate increases as the end of the 10-min period approaches. The behavior shows the effect of the fixed-ratio component in the relatively high rates of response that occur.

Figure 1 shows sample cumulative records for fixed-interval, fixed-ratio, and tandem schedules of reinforcement, in *A, B,* and *C,* respectively. Cumulated number of responses is along the ordinate; time is along the abscissa. *A* shows a record for a 10-min fixed interval. Five successive 10-min intervals are shown. The pen is reset to the bottom of the record after each reinforcement. The typical characteristics of each fixed-interval performance are the initial period of no responding and the subsequent positive acceleration in the curve up to a terminal rate of about two responses per second. *B* shows records for a fixed ratio of 25 responses. The short diagonal strokes to the right of the record indicate reinforcements. The rate here is four to five responses per second and there are no pauses. In *C,* a sample record for a tandem (fixed interval of 10 min, fixed ratio of 12 responses) is shown. There are again five successive intervals, the pen being reset after each reinforcement. Although the performance here retains the positive curvature of the ordinary fixed interval, it can be seen that the over-all rate of response is much higher than in the ordinary fixed interval and that there is some tendency for short groups of responses at high rates to occur. Both of these differences from ordinary fixed-interval performance can be attributed to the presence in the tandem schedule of the small fixed-ratio component.

The effect on the fixed-interval performance of 2 mg of sodium pentobarbital, injected intramuscularly 5 min before the start of the record, is shown in *A*1. The effect is clearly one of depression, even though casual observation of the pigeon's general activity would not reveal any disturbance. The second interval in *A*1 contained only one response, the reset of the pen is therefore absent for this interval. The first and third intervals exemplify another frequently observed effect of pentobarbital, in addition to the depression. In these two intervals, the response curve did not show the positive acceleration that is typical of normal fixed-interval performance.

*C*1 shows the tandem performance 5 min after the intramuscular injection of 4 mg of sodium pentobarbital. The drug has again resulted in an over-all depression of responding. There is, in addition, no evidence of positive curvature in each interval and almost all low or intermediate rates of response have disappeared.

The 10-min period is now filled with groups of responses at high rates and periods of no response. This record is typical of others obtained after injection of sodium pentobarbital with a tandem-schedule base line.

The result obtained by Dews seems to be confirmed here by the use of a different experimental technique. Dews showed that the behavior maintained by fixed-ratio schedules was much more resistant to sodium pentobarbital than that maintained by fixed-interval schedules. In the present experiment, a tandem schedule was used, combining features of both fixed-interval and fixed-ratio schedules. The behavior generated by the tandem schedule shows both the progressive increase in rate typical of fixed-interval performance and the rapid responding characteristic of fixed-ratio performance. Sodium pentobarbital, by its selective interference with these two forms of responding, served to fractionate the tandem-schedule performance. Both effects of sodium pentobarbital on fixed-interval behavior were observed when the tandem schedule was the base line. There was both the depression in rate and the loss of positive curvature in the record. The rapid, fixed-ratio responding, which is insensitive to sodium pentobarbital when a fixed-ratio schedule alone is used as a base line, was not, however, disrupted by the drug. These findings serve the dual function of further substantiating the selective action of sodium pentobarbital and of being a demonstration of the presence of fixed-interval and fixed-ratio components within the tandem-schedule performance.

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22 June 1956

Fish Scales in a Sediment Core from Linsley Pond, Connecticut

During a study of the LV sediment profile (*1*) from Linsley Pond, Connecticut, two fish scales were found at depths of 25.0 and 24.2 m below the present water surface (10.2 and 11.0 m below the mud-water interface). The scales were found in sediments of the lower Cl pollen zone. The radiocarbon dates for the upper and lower Cl pollen zones are 5200 and 8300 years, respectively, (*2*). The scales are therefore located in sediment that is approximately 7500 years old.

Fig. 1. Fish scale from 24.2-m depth in sediment of Linsley Pond, Connecticut. (approximately × 22).

Fig. 2. Scale of golden shiner, *Notemigonus crysoleucas.* (approximately × 26).

Following Lagler's key to scales of Great Lakes fishes (*3*), the older of the two scales (25.0-m depth) was identified plausibly by Vallentyne as a scale from a member of the family Cyprinodontidae, of which there is only the banded killifish, *Fundulus d. diaphanus,* in Connecticut's lakes now (where reportedly they are restricted to sandy-gravelly shoals (*4*). This scale was lost inadvertently.

A photograph (Fig. 1) of the younger scale (24.2-m depth) shows one apparent annulus; the fish was nearing its second birthday at least. The characteristics of this scale further indicate that it came from a member of the minnow family, Cyprinidae. The present-day native minnows of Connecticut are fallfish (*Semotilus corporalis*), creek chub (*Semotilus atromaculatus*), blacknose dace (*Rhinichthys atratulus*), common shiner (*Notropis cornutus*), cutlips minnow (*Exoglossum maxillingua*), bridled shiner (*Notropis bifrenatus*), golden shiner (*Notemigonus crysoleucas*), and spottail shiner (*Notropis hudsonius*) (*4*).

The find resembles "typical" scales of the last two of the foregoing and quite clearly of none of the rest. Comparison is made difficult by the facts that the Cl specimen is somewhat fragmented, that its central area (focus) is eroded (almost certainly it is a replacement scale and not one of the fish's original complement), and that there is variation in scale configuration and visible components from place to place on a fish. Identification as golden shiner (see Fig. 2), *Notemigonus crysoleucas,* is preferred to that as spottail, *Notropis hudsonius,* because of the small number and angles of the radii and on grounds of contemporary ecology. *Notemigonus* is the most common Connecticut lake minnow (*4*) —also predominantly lacustrine elsewhere in its range—although it is locally abundant in the Great Lakes. There is no evidence for concluding that the Cl cyprinid scale is from a species once but no longer extant in the pond drainage.

This appears to be the first instance in which single fish scales have been found in lake-sediment cores. The scales were encountered only by accident. A thorough and premeditated search for scales in lake sediments might provide data bearing on fish succession during lake history. Providing that the scales could be specifically identified, the information obtained would be of considerable interest to paleobiogeographers and limnologists alike. The presence of scales from cold stenothermal fishes would be of particular interest in relation to the obliteration of the hypolimnion as the lake basin filled in (*5*).

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5. This work was supported by the National Research Council of Canada.

23 July 1956

Correction

In our paper "Mitochondrial self-duplication observed *in vitro*" [*Science* 124, 123 (20 July 1956)], the authors of two of the references were incorrectly given. The authors for reference 5 are E. P. Kennedy and A. L. Lehninger; the authors for reference 6 are J. W. Harman and M. Feigelson.

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