A GENETIC STUDY OF BRAIN DIFFERENTIATION BY THE ACTION CURRENT METHOD.

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PREFACE

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I. INTRODUCTION.

In current neurology and psychology the genesis of brain functioning in the animal scale has been attacked largely from an anatomical standpoint. In some cases these studies were supplemented by experimental techniques which involved destruction of brain tissue, but the procedure was for the most part to allow an anatomical theory to dictate the results of physiological experimentation. Notable exceptions, such as the work of Lashley (27) and Coghill (15), are, of course, too well known to require special review.

The application of the action current technique to the study of the cerebral cortex by Bartley (6), Newman (29) and Perkins (31), opened a wide field of attack which emphasized the functional, rather than the purely anatomical, aspect of problems pertaining to the nervous system. At the same time, these studies relied upon the normality of the animal subject for trustworthy conclusions. It seemed equally obvious that such a technique would offer an important clue to a comparative study of brain functioning.

The present study is concerned with a comparison of five divisions of the animal kingdom, namely, the Crustacean, Amphibian, Reptile, Bird, and Mammal. An attempt was made to record action currents from the brains of these animals under as uniform and as normal conditions as possible, in order that an adequate functional comparison of these groups could be made.

Several problems arise which this investigation has sought to answer. First, What is the trend and character of the rela-

tive gross differentiation of brain activity as one proceeds up the animal scale? Second, How does the same stimulus affect the brains of these different forms? Third, Is the same stimulus-response relationship maintained as one ascends the animal scale, or, are there entirely different relationships appearing at the various stages? Fourth, Are the trans-cortical gradients, if any, like those found by Bartley and Perkins in the dog, under different stimulus-response situations? Fifth, Can definite laws, describing the evolution of the brain, be formulated from the results of experimentation of this kind? Sixth, To what extent is current theory, in comparative psychology, consistent with the functional differentiation of the brain as revealed by action current studies?

In formulating answers to these questions the present study will be concerned with an analysis of the action current records primarily from the standpoint of amplitude and gross pattern. Frequency and wave-form are without the scope of this thesis.

The only previous action current studies on the functioning of the central nervous system are those of Bartley and Perkins (6, 31) which will be reviewed in the section on conclusions. Since historical summaries occur in these studies no general historical section will be included here. Relevant experiments will be mentioned in the section on conclusions, and directly compared with the results of the present study.

II. METHOD

(1). Apparatus - In the present study the apparatus was identical with that employed by Bartley (6) and Perkins (31), and is a modification of the apparatus described in detail by Newman (29). For details, therefore, the reader is referred to these sources. However, for the sake of continuity, a brief resumé of the essential features of the apparatus will be given here.

The apparatus can be divided, for descriptive purposes, into three sections: (1) the amplifying set and accessories; (2) the oscillograph; and (3) the camera.

The amplifying set consisted of five stages of vacuum-tube amplification. The first three stages were located in the operating room, which was shielded on all sides, and floor, with metal and celotex or wood. In addition to the room shielding the tubes and entire set were shielded. Direct battery current for room illumination, and for the operation of the first three stages, was available in the room, in order to exclude extraneous alternating current. The output leads from the first three stages passed out through the wall of the operating room across another room to the last two stages of amplification. The tubes of the set were continuously grounded. Occasionally the last two sets were shielded for recording and for tests. Shielding of these sets was not so important as was shielding of the first three stages, since an extraneous current at this point would receive relatively little amplification. The last power tube was connected with a loud

speaker unit which passed into the operating room as an aid to the operator. In experiments FF and part of EE, the full strength of the power tube was cut in and the speaker eliminated, thus increasing the amplification. In all the other experiments the speaker was used in the circuit so that only four tubes and part of the fifth were employed in magnifying the action currents. The output leads from the amplifier passed to the oscillograph element.

A Westinghouse Oscillograph element was used as the galvanic instrument. The advantages of this instrument over the string galvanometer, phoneloscope or capillary electrometer, are too well known to mention here in detail, but are essentially, the high frequency of vibration and the relative lack of friction, made possible by the practically instantaneous dampening of the torque exerted on the string. The light source, supplied by an Eastman Kodascope lamp, passed through a system of prisms provided in the standard Westinghouse optical system. The optical system and oscillograph element were arranged in a box designed after the multi-element Westinghouse oscillograph instrument. The light beam passed out of the box through a large cylindrical lens, which was part of the optical system, into the camera box.

The camera box was specially designed in galvanized sheet iron and fitted into the grooves on the outer part of the optical box. An aperture was made in the side of this box which coincided with the lens of the optical box. 70 mm. motion picture film ran through a groove on the inside of the box, directly in the path of the light-beam. The film passed over

a specially constructed sprocket, which could be rotated by a pulley wheel and a constant speed motor, or by a crank turned by hand. The latter method was used throughout the present experiments, since the motor affected the amplifying set.

(2). Controls - Controls on the amplifying set and the general experimental set-up were made extensively by Bartley (6) and Perkins (31) and demonstrated without question the valid nature of the results. In the present experiment these same controls were repeated as a measure of caution and certain additional checks were made. These tests can be grouped into three types: (1) behavior tests, (2) experimental tests, and (3) general tests.

The behavior tests include those records taken with the animal in circuit, but passive, with no particular stimulation. It will be noted later that a large number of these tests were made on each animal, preceeding the records with stimulation. For the most part these records show a fairly steady base-line, with which to evaluate the other records. Included in this group, also, are the records taken from animal G. In this case the animal, a frog, died before the operation, and all of the records were taken from the brain of the dead animal. It will be noted that the check records taken under several types of stimulation---sound, visual and motor---are all negative.

Experimental tests include those records taken during a given period of recording, in which the animal was not in circuit. In every experiment, records were taken with the switch

on closed circuit. It will be noted that the records are negative, but may, at times, show slightly 'fuzzy' baselines. Other records were taken from time to time with the switch on open circuit. These records show 'fuzzy' baselines which are very regular. Tests of this kind proved it necessary that the experimenter stand on felt pads, to prevent jarring of the floor. Direct observations of the oscillations, which were not recorded, were made constantly throughout the course of the experiments.

The general tests include these records taken when no operation was in progress, for the purpose of insuring efficient operation of the amplifier. Tests were made with different types of grounding, with open and closed circuit, with different switch contacts, with different tubes in the set, and with different battery bias to the set. The details of these tests, most of which were not photographed, are too numerous to describe here. Suffice it to say that the best performance of the amplifier was selected for use in all of the experiments.

Data have already been presented (Perkins (31))which demonstrate that the records from the animal's brain are nervous in origin. To summarize them: 1. The high frequencies of the records are inconsistent with slow muscle action currents; illustrations of nerve action currents in the literature are similar to those obtained in the present experiment; 2. the nerve preparation was insulated from muscle by the cranium; 3. the magnitude of the record is not a function of the distance from the muscle; 4. large amplitude records are obtained when

the animal is passive; 5. electrodes placed proximal to muscle tissue failed to pick up muscle action currents. From the above controls it is believed that the validity of the relative amplitude of the records and the types of grouping which the throws exhibit cannot be disputed. The frequency of the throws, however, cannot be directly validated. Although the bulk of evidence of an indirect character, and comparisons with the work of Gasser and Erlanger (17, 18), Adrian (1), Adrian and Zotterman (2), and Bartley and Bishop (11) demonstrate that the frequencies found on our records fall within the range of nerve frequencies, the aspect of frequency has been ignored until more experimental checks are available.

(3). Description of Animals - The animal subjects were representative of five groups, selected at significant steps in the evolutionary scale. (a) Crustacea, Astacidae, species Cambarus affinis. Four small crayfish were used as examples of this group. They were subjects in experiments E, H, L and N.

(b). Amphibia, Anura, species Rana pipiens. Two sizes of grass frogs were employed as representatives of this group. The small frogs measured 5 inches, and the large, 11 inches in length. Recording was made from 11 animal experiments A, B, C, D, F, G, I, J, K, M and O. Frog G was used as a check animal since it was dead during the recording.

(c). Reptilia, Ophidia, species Pityophis sayi. A bull snake was used as an example of this group. The same snake was used in two experiments V and W.

(d) Aves, Carinatae, species Columba livia. The representative of this group was the common pigeon. Recording was made from 8 animals in experiments P, Q, R, S, U, BB, GG, and II.

(e). Mammalia, Eutheria, Rodentia, genus Mus. The domesticated laboratory rat was used as the subject for this group. They included rats with pigmented eyes and albinos. There were in all 10 animals; experiments T, X, Y, Z, AA, CC, DD, EE, FF, and HH.

(4). Operative Technique - The operative technique differed somewhat with different types of animals. In the crayfish, frog and snake, no anaesthetic was employed. The animal was fastened to an operating board and the skin or the exoskeleton removed. In the case of the crayfish the exoskeleton was cut with a circular power-saw and the connective tissue underneath teased aside with a probe. In the case of the frog and snake an incision was made in the cranium with a sharp scapel, the opening enlarged with clippers to the desired size. The animal's brain was irrigated throughout the experiment with Ringer's solution, except during actual recording. Several of the frogs, and the snake, were operated on three hours or more in advance of the experiment. In certain instances the operation occurred on the day preceding the experiment, and the opening closed over, meanwhile, with wax. This was done as a check to ascertain if the operative technique caused sufficient cortical disturbance to affect the records. No such disturbance could be discovered. The records following one hour after the

operation were, in general, similar to those following the operation by 24 hours.

The oporative technique was somewhat more complicated in the rat and pigeon. In many ways was similar to that used on the dog and has, therefore, already been described in detail (6, 31). The animal was placed under a general ether anaesthetic and fastened securely in a special cradle. The neck of the pigeon was fastened into a loose clamp with adhesive tape so that the head was held securely. The rat's head rested on a clamp in such a way that the lower jaw was forced open and down by a cord around the lower teeth. The animal's feet were secured with tough cord. A wide gauze bandage was wrapped around the pigeon and fastened to the holder.

As soon as the animal was fastened securely the head was clipped, and 1 to 2 cc. of 2 per cent novocaine solution was injected into the muscles of the head and neck, so that the later wearing off of the general anaesthetic would not leave the animal in pain. An incision was made down the median line of the head and the skin fastened back from the cranium, with hemistats. The muscles and fascia were teased back with a blunt probe so that the cranium was freely exposed. In the rat it was necessary to loosen the jaw muscles from their connection on the ridge of the cranium and to cut their connections on the posterior end so that the cranium could be fully exposed.

A rectangular incision was then made in the bone with a circular power-saw. In the case of the rat this incision was

only on one or the other side, since hemorrhaging was encountered at the median line. In the pigeon, however, it was found satisfactory to make a large open rectangle across the median line. This opening was then enlarged with special clippers to include the amount of the forebrain desired. The meninges were carefully removed and the electrode holder inserted into place. The animal then recovered from the general ether anaesthetic over a 45 minute or hour period before the recording was begun. During the entire time the brain was exposed, except during actual recording, the brain was irrigated with Ringer's solution at a constant body temperature. This solution was piped into the operating room from a constant temperature water bath designed after Taft (32) and already described by Bartley (6).

(5). Electrodes - There were three types of neutral electrodes used in the experiments. In the first experiments on the frog the neutral was a silver clamp fastened to the foot or skin of the animal. Later this was substituted for a clamp which fastened to the forward end of the bone opening. In the snake a similar clamp was fastened to the bone. In the crayfish, rat and pigeon a metal clamp, which contained a celluloid electrode holder, was used. This clamp was inserted under the bone and a set screw tightened so that the clamp and holder moved only when the bone moved. This insured simultaneous movement of the electrode and the animal. The electrode holder was a celluloid strip, with groves, that held the wires to the electrodes.

The active electrodes were the same throughout the ex-

periment. They were composed of fine silver wire which was looped at the end, and flattened, so that a flat piece of silver wire of 2 to 3 mm. length made contact with the brain. The wire and the rest of the loop were encased in a wax matrix so that a circular area actually made contact with the surface of the brain. This meant that the brain tissue would not be punctured. In most of the experiments there were two of these electrodes.

The electrode wires passed into a common insulated cable, connected with a multiple contact switch, consisting of a slide supplied with double paws running over copper plates, one of which lead to the neutral electrode and the other to the active. One point on this switch was on a closed circuit, while the other was open. This switch arrangement saved manipulation of the electrodes while the recording was taking place.

(6) Stimuli - The stimuli used in the various experiments can be grouped into four general classes: visual, auditory, motor, and pain. There were several different types of stimuli in each of these groups. (a). Visual. (1) Room light. This stimulus was used in all the other stimulus-situations except the remainder of the visual, and consisted of a headlight bulb illuminated with direct battery current, situated directly above the operating table. (2) Total Darkness. This was merely the absence of the room light. (3). Flashlight. The room light was turned off and as the record started a hand flashlight was turned into the animal's eyes. (4). Flashlight 3 times. In several cases the flashlight was turned

off and on three times, so that the results of a flickering light could be recorded. (5). Match. In a few cases a match was lighted in the animal's eyes, instead of the flashlight.

(b). Auditory. (1) Quincke tube. A 1024 d.v. quincke tube was blown into the animal's ear. In some cases this whistle started the record; in others it was given after the record started. (2). 325, 387, and 488 d.v. tuning forks. The tuning forks were sounded into the animal's ear, either at the start of the record or after the record had commenced. (3). High and low siren. A few records were taken with a siren, consisting of a cog-wheel fastened to a hand color-mixer, making contact with a celluloid strip. This siren had either a frequency range from the lower limit to about 400 d.v. as the low siren, or a range up to 2,000 d.v. as the high siren. (4). D-major Harmonica. This was a pitch-pipe which could be blown at the high or the low end. (5). Galton whistle. An Edelman Galton whistle was sounded, near the upper limit, in the animal's ear.

(c) Tactual and Kinaesthetic. (1). Pulled cord attached to legs. In this case there were cords fastening the animal's legs to the operating board, which were released. The animal's legs flexed and extended. (2). Punched eye. The animal's eye was punched or touched with the rubber end of a pencil in order to elicit the eye-lid reflex. (3). Tapped back or head. The animal was tapped with the rubber end of the pencil, on the back or head. (4). Stroked body or feathers. The animal's back or legs or feathers were stroked with the rubber end of a pencil. (5). Blew. The experimenter blew at the animal's

head. (6). Rubbed back. The experimenter rubbed the animal's back lightly with the rubber of the pencil.

(d). Pain. (1). HCL on skin. In the frog a drop of HCL acid was placed on the back or leg. As soon as the animal had responded the acid was carefully washed off the skin. (2). Punched leg, back, neck or bill. The experimenter punched with the point of a pencil rather vigorously either, leg, back, bill or neck. (3). Pulled tail. The experimenter pulled the animal's tail rather vigorously. (4). Punched inside mouth. In the case of the snake the animal's mouth was punched with the pencil point. (5). Hit feet. Particularly in the pigeon the animal's feet were hit several times with a pencil.

(e). Syncronization of stimulation and records. All the records of this investigation were started by an assistant at the word "take", preceded by "ready", given by the experimenter. The instant the sound of the rolling film was heard by the experimenter he applied the stimulus. Each record lasted during one to three (sometimes more) revolutions of the sprocket, a time interval ranging from two to ten seconds. The response of the animal could be "heard" through the loud-speaker. The records varied from 200 to 1000 mm. in length, but were mostly between 200 and 500. The simultaneity of noises from the loud speaker and the turning of the record was relied upon as evidence that the animal's response was being photographed. With practice it was found an easy matter to accomplish. The shortness of the majority of the records also insures against artificialities and ambiguities. Tests in which specific stimuli were applied a given number of times showed a corresponding

number of bunched throws on the record.

(7). System of Classification of Records - For the sake of continuity, and to enable comparisons to be made between the dog and the animals represented in this study, the same classification system for the records was used as in Bartley (6) and Perkins (31). First, in each record the electrode position is indicated. For the most part the architectural designation is arbitrary in that the brain was divided, for convenience into several regions to facilitate control of electrode locations. Maps of the animal's brain are presented at the end of each section giving the location of the areas. Second, in the description of the records the term amplitude will appear frequently. At the end of each description there will be a type number followed by a number in parenthesis. The latter number designates the amplitude of the record. The value 4 represents maximum amplitude, a range from 15 to 50 mm. or over. The range from 8 to 15 mm. in height is given the value of 2. Those records with slight amplitude will be designated as 1, and range in height from 5 to 7 mm. Those records which are below 5 mm. in amplitude will be classed as zero amplitude. It was found advisable to omit the value 3 since the jump from the range designated as 2 to higher amplitude was generally abrupt. (See Plate I for examples of amplitude scale).

Third, the pattern of the record is included in the description. In some of the records the throws came in series or volleys, that is, in a single group, all approximately the same amplitude. These series were of two types, the abrupt,

PLATE 1

which commenced at a maximum from a fairly steady baseline, and those which gradually increased and decreased in amplitude. The extent or duration of the series is also noted. By a peak in the series is meant the point near the center of the volley where maximum amplitude occurs. By the term baseline is meant the condition found under closed circuit or with the animal passive and under no experimental stimulation. This is not a perfectly smooth baseline in all instances but does not contain excursions exceeding 3 to 4 mm. in amplitude.

Fourth, after each report a type number is given which locates that record on a scale of classification. This type number is based on a systematic plan which includes all the general types of records found. The plan of classification is modified from Bartley (6). The most general grouping that appeared was the negative as opposed to the positive records. The negative records contained either a smooth or slightly rough baseline, with no throws that could be considered significant. These records compare very favorably with the records taken under closed circuit. The positive records include all that show any differentiation of cortical activity. The records are classified as follows:

Type 1. A negative or nearly negative record. This type is shown in Plate II, figure 1.(0)

Type 2. The throws are intermittent in distribution throughout the record; they are large and uniform in amplitude. The series of impulses are of short duration. This type is shown in Plate II, figure 2.(4)

Type 3. This type is also intermittent, large and regular in amplitude. It differs from type 2 in that the series of impulses are long. It is illustrated in Plate II, figure 3. (4)

Type 4. In this type the record is intermittent with throws of large amplitude. However, the throws are irregular in nature and occur in short series. See Plate II, figure 4. (4)

Type 5. This type is intermittent, large in amplitude, and irregular in character of throws. It differs from type 4 in that the throws occur in longer series. See Plate II, figure 5. (4)

Type 6. In this type the record is intermittent, the impulses small in amplitude, regular in character of throws, but occur in short series. See Plate II, figure 6. (2)

Type 7. This type is intermittent, small in amplitude, regular in character of throws, but the throws are in long series as opposed to type 6. Plate II, figure 7, illustrates this type. (2)

Type 8. In this type the disturbance on the record is intermittent, the impulses small, but irregular in nature. The series of impulses are short. Plate II, figure 8, shows this type. (2)

Type 9. This type is intermittent, small in amplitude, irregular in nature of throws and the throws occur in long series. Plate II, figure 9, shows an illustration of this type. (2)

Type 10. This record is the first of the second main group,

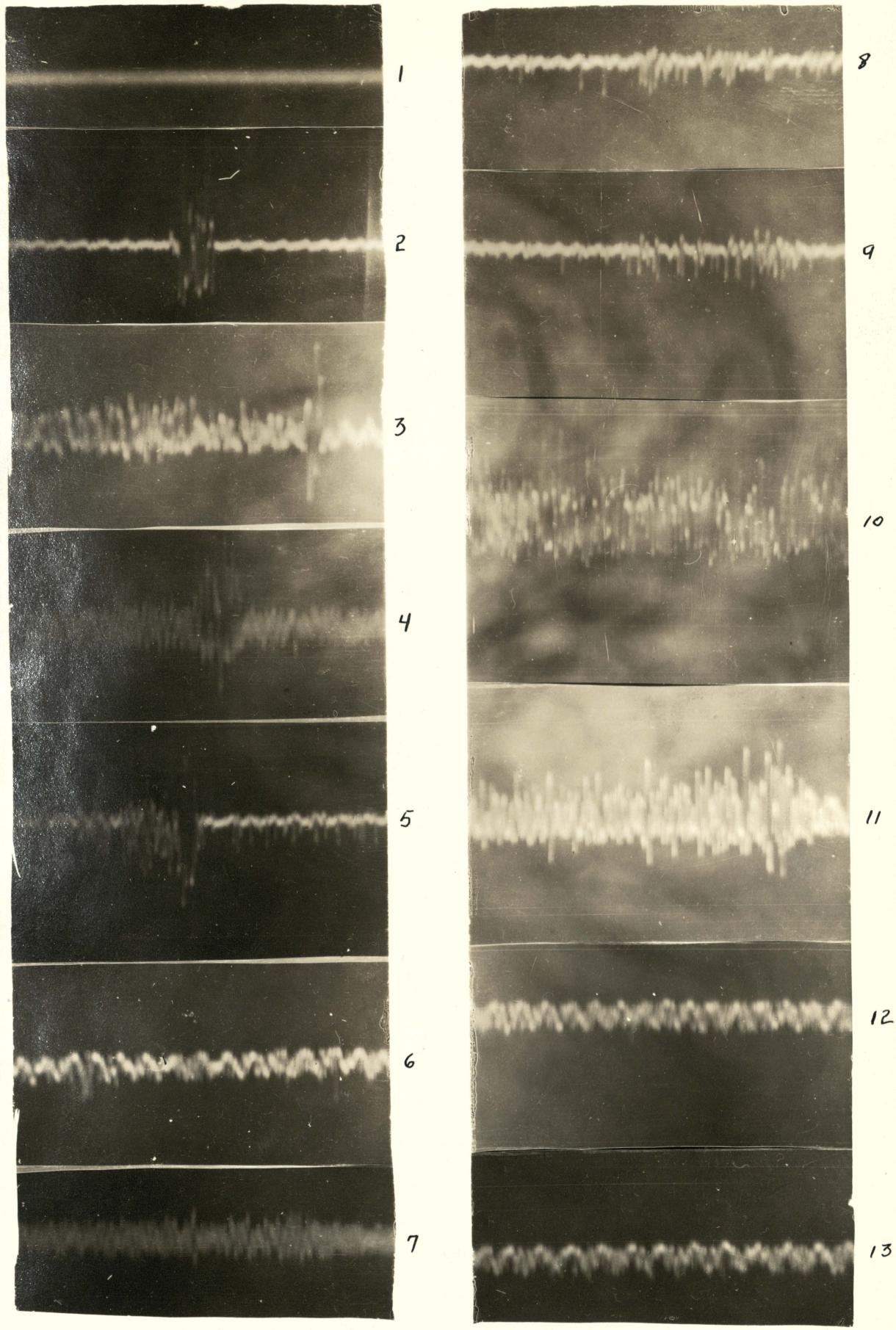

PLATE II

those which show extended series of throws throughout the record. The throws in this case are large in amplitude and the impulses regular in nature. Plate II, figure 10, shows an illustration of this type. (4)

Type 11. This type is extended, large in amplitude and irregular in nature. An illustration of this type is shown in Plate II, figure 11. (4)

Type 12. In this type the record shows extended activity, which is small in amplitude and the throws are regular in nature. Plate II, figure 12, shows an illustration of this type. (1)

Record 13. This type is extended, small in amplitude, but the throws are irregular in nature. See Plate II, figure 13, for an illustration of this type. (1)

This classification proceeds in logical order through the thirteen types, but does not indicate the extent of differentiation shown on the record. The various types, therefore, have been given an evaluation as far as grossness of disturbance on the record is concerned. This evaluation appears in parenthesis at the end of each of the above descriptions. Four degrees of disturbance have been chosen as was mentioned above: zero, one, two, and four. In case the classification of a record fell on the borderline between two ranges of amplitude it could be given an evaluation between the numbers. This mid-classification is designated in the reports as a certain type with either a plus or a minus sign attached.

It will be noted that all records of 0 amplitude evaluation are of type 1; records of amplitude evaluation of 1 include types 12 and 13; the evaluation of 2 includes types 6, 7, 8 and 9; and 4 includes types 2, 3, 4, 5, 10 and 11.

Generally one to three readings with a millimeter scale were sufficient to establish an approximately average magnitude for a given record. At other times, several were necessary. Where a record greatly predominated in large throws these were taken as representative of the record. Where a single wide throw appeared, but the record was predominantly of low amplitude, the lower range was regarded as typical.

III. THE CRUSTACEAN

(1). Description of Experiments and Records. In the four experiments on the crayfish, there were 121 records taken. A description of the experiments and each record, with its classification, the stimulus, and the animal's response, follow. It will be noted that the electrode positions are indicated after each report. Plate III shows a diagram of the cerebral ganglia of the crayfish with arbitrary divisions used in keeping track of electrode positions. There are six of these electrode positions. On the diagram are also circles in which the letter designation of the experiment is inserted; the position of the circle marks the position of the electrodes.

Crayfish E March 22, 1933, 8:00 p.m.

Electrodes: The neutral electrode was a jack fastened to the posterior side of the skeletal opening. Active electrode 1 was placed on the left ant. lat. cerebral ganglion. No. 2 was on the right ant. lat. cerebral ganglion.

Description of Records:

Record 1. Animal passive in room light. Electrode: left ant. lat. cere. gangl. The record shows a fairly long series which reaches 10 mm. in amplitude. Type 9, amplitude (2).

Record 2. Animal passive in the room light. Electrode: rt. ant. lat. cere. gangl. There is a fairly long series near the first of the record which reaches 12 mm. in amplitude. Type 9 (2).

Record 3. Punched animal's back with pencil. Animal raised body slowly. Electrode: rt. ant. lat. cere. gangl. The record shows a long irregular series of 10 mm. amplitude. Type 9 (2).

Record 4. Punched animal's back with pencil. Animal raised body slowly. Electrode: left ant. lat. cere. gangl. The record shows regular activity of 6 and 7 mm. amplitude. Type 12 (1).

Record 5. Touched animal's front left pincher. Animal moved slightly. Electrode: left ant. lat. cere. gangl. The record

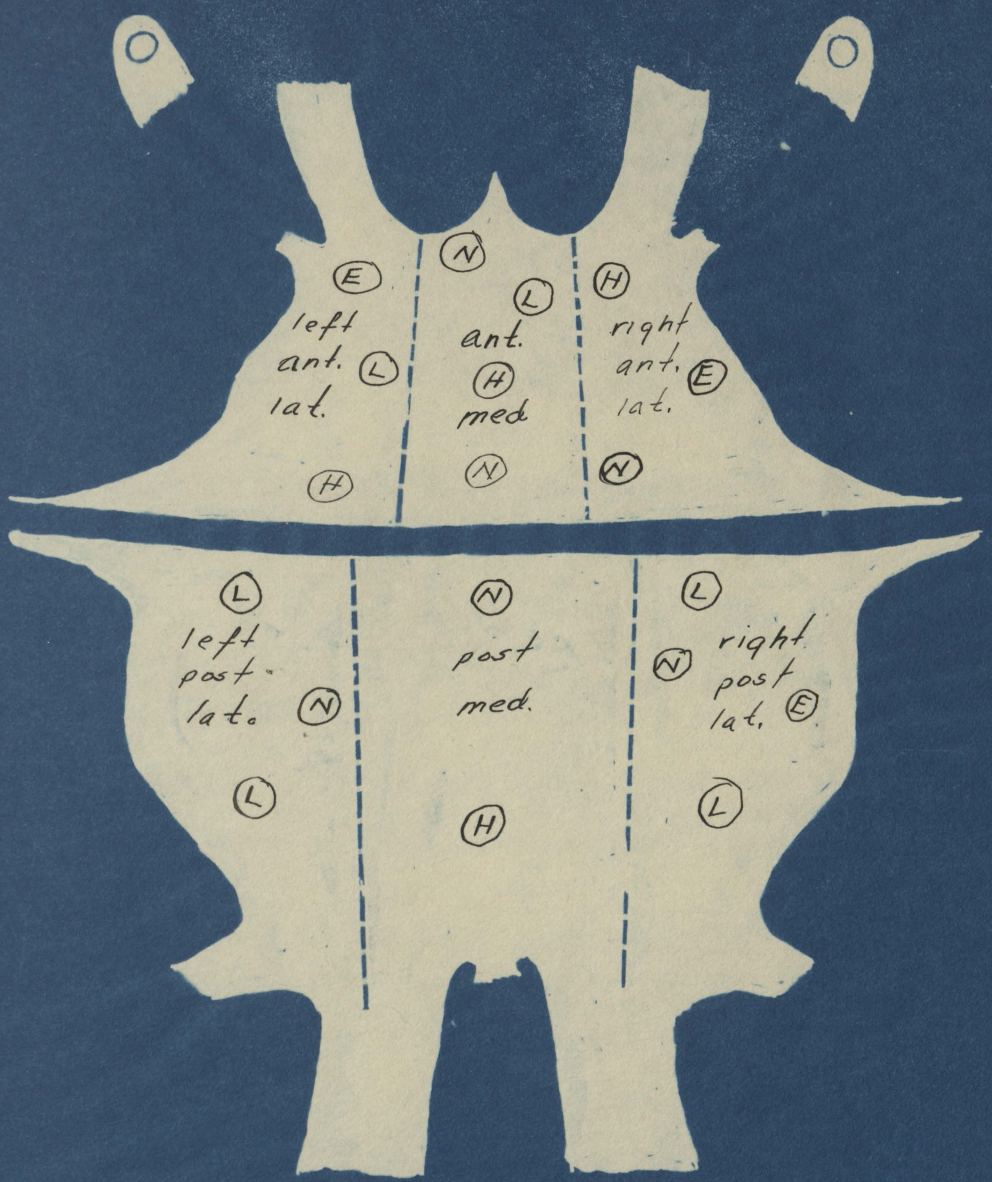
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PLATE III

shows two irregular short series which reach 20 mm. in amplitude. One in the middle of the record and one at the end. Type 4 (4).

Record 6. Touched animal's front left pincher with pencil. Animal moved slightly. Electrode: rt. ant. lat. cere. gangl. There are two very short series which reach 20 mm. in amplitude. Both are in the middle of the record. Type 2 (4).

Record 7. Punched the front of animal's pincher with pencil. Animal moved slightly. Electrode: rt. ant. lat. cere. gangl. The first 10 mm. of the record are quiet. At this point there occurs an abrupt series which reaches 25 mm. and then tapers off into irregular 15 mm. activity to the end of the record. Type 11 (4).

Record 8. Touched animal's right front pincher with pencil. Animal moved slightly. Electrode: rt. ant. lat. cere. gangl. The record is nagative. Type 1 (0).

Record 9. Touched animal's right front pincher with pencil. Animal moved slightly. Electrode: left ant. lat. cere. gangl. Just after the record started there is a short series which reaches 22 mm. in amplitude. Type 4 (4).

Record 10. Hit left pincher of animal with pencil. Animal moved slightly. Electrode: left ant. lat. cere. gangl. The record shows irregular activity throughout reaching an amplitude of 18 mm. Type 11 (4).

Record 11. Tapped animal's back with pencil. Animal raised body. Electrode: left ant. lat. cere. gangl. The record shows a short series just after the record started which reaches 22 mm. in amplitude. This series is irregular. Type 4 (4).

Record 12. Tapped animal back with pencil. Animal raised body. Electrode: left ant. lat. cere. gangl. The record shows irregular small activity until the last of the record when there is a very short series which reaches 40 mm. in amplitude. Type 2 (4).

Record 13. Tapped animal's back with pencil. Animal raised body. Electrode: left ant. lat. cere. gangl. The record shows irregular activity of 6 and 7 mm. throughout. Type 12 (1).

Record 14. Punched animal's left eye with pencil. Animal passive. Electrode: rt. ant. lat. cere. gangl. The record is negative. Type 1 (0).

Record 15. Sounded quincke tube at right side of animal. Animal passive. Electrode: rt. ant. lat. cere. gangl. The record shows an irregular series throughout the record which reaches 25 mm. in amplitude. Type 11 (4).

Record 16. Sounded quincke tube on right side of animal. Animal passive. Electrode: left ant. lat. cere. gangl. The record shows extended activity of irregular nature which reaches 15 mm. in amplitude. Type 11 (4).

Record 17. Tapped animal's back with pencil. Animal raised body up high. Electrode: rt. post. lat. cere. gangl. The first 70 mm. of the record are quiet. From this point on there is large activity to the end of the record which reaches 30 mm. in amplitude. The record is irregular. Type 11 (4).

Record 18. Tapped animal's back with pencil. Animal moved body sidewise. Electrode: rt. ant. lat. cere. gangl. The record shows extended irregular activity which reaches 20 mm. in amplitude and extends throughout the record. Type 11 (4).

Record 19. Tapped animal's back with pencil. Animal winced. Electrode: rt. ant. lat. cere. gangl. The record shows irregular medium activity throughout with one short series after the center of the record which reaches 45 mm. in amplitude. Type 2 (4).

Record 20. Tapped animal's back with pencil. Animal winced. Electrode: left ant. lat. cere. gangl. The record shows small throws of 6 and 7 mm. amplitude regularly throughout the record. Type 12 (1).

Record 21. Animal spontaneously raised body high in the air. Electrode: left ant. lat. cere. gangl. The record is regularly active at the 6 and 7 mm. amplitude. Type 12 (1).

Record 22. Animal spontaneously raised body. Electrode: rt. ant. lat. cere. gangl. The record shows uniform activity of 7 and 8 mm. amplitude throughout the record. Type 12 (1).

Record 23. Animal spontaneously raised body. Electrode: rt. ant. lat. cere. gangl. The record shows small activity until near the end of the record when a short series of 10 mm. amplitude occurs. Type 8 (2).

Crayfish H April 6, 1933, 8:00 p.m.

Description of Records:

Record 1. Animal passive in the room light. Electrode: left ant. lat. cere. gangl. The record is negative. Type 1 (0).

Record 2. Animal passive in the room light. Electrode: rt. ant. lat. cere. gangl. The record shows scattered throws of 5 and 6 mm. amplitude in the center of the record. Type 13 (1).

Record 3. Hit animal's hind leg with pencil. Animal passive. Electrode: rt. ant. lat. cere. gangl. The record shows scattered throws of 5 and 6 mm. amplitude. Type 13 (1).

Record 4. Touched animal's mandible with pencil. Animal passive. Electrode: rt. ant. lat. cere. gangl. Starting with the center of the record there is a fairly long series of throws which reach 9 mm. in amplitude. Type 9 (2).

Record 5. Hit animal's mandible with pencil. Animal winced. Electrode: rt. ant. lat. cere. gangl. The record shows several fairly long series which reach 11 mm. in amplitude. Type 9 (2).

Record 6. Shined flashlight into right eye of animal. Animal passive. Electrode: left ant. lat. cere. gangl. The record shows an extended series which reaches 16 mm. in amplitude. The record is very irregular. Type 11 (4).

Record 7. Shined flashlight into right eye of animal. Animal passive. Electrode: rt. ant. lat. cere. gangl. The record shows several short series which reach 9 mm. in amplitude. Type 8 (2).

Record 8. Punched animal's left eye with pencil. Animal passive. Electrode: left ant. lat. cere. gangl. The record shows two short series, one in the center of the record and one in the last fourth, which reach 10 mm. in amplitude. Type 8 (2).

Record 9. Hit animal's mandible with pencil. Animal passive. Electrode: left ant. lat cere. gangl. The record shows medium activity throughout with a very short series superimposed in the last fourth of the record, which reaches 45 mm. amplitude. Type 2 (4).

Record 10. Animal spontaneously pinched pencil with claw. Electrode: left ant. lat. cere. gangl. The record shows uniform activity of 10 mm. amplitude throughout the record. Type 7 (2).

Record 11. Animal spontaneously pinched pencil with claw. Electrode: left ant. lat. cere. gangl. The record shows uniform activity of 10 mm. amplitude throughout the record. Type 7 (2).

Record 12. Animal spontaneously pinched pencil with claw. Electrode: rt. ant. lat. cere. gangl. The record shows several short series of 10 mm. amplitude. These occur more frequently in the last half of the record. Type 8 (2).

Record 13. Sounded 325 d.v. tuning fork on right side of animal. Animal pssive. Electrode: rt. ant. lat. cere. gangl. In the last half of the record there are two fairly long series which reach 30 mm. in amplitude. The first half of the record shows small activity. Type 5 (4).

Record 14. Sounded 325 d.v. tuning fork on right side of animal. Animal passive. Electrode: left ant. lat. cere. gangl. The record shows a long regular series which reaches 10 mm. in amplitude. Type 7 (2).

Record 15. Closed circuit. The record is fairly quiet but 'fuzzy'. Type 1 (0).

Record 16. Animal spontaneously crawled up on block. Electrode: rt. ant. lat. cere. gangl. The record shows a long series of 10 mm. throws. In the last half of the record there is a short series which reaches 30 mm. in amplitude. Two of the throws are due to movement of the electrodes. Type 5 (4).

Record 17. Animal passive in the room light. Electrode: Post. med. cere. gangl. The record is negative. Type 1 (0)

Record 18. Animal passive in the room light. Electrode: Ant. med. cere. gangl. The record is negative. Type 1 (0).

Record 19. Shined flashlight into right eye of animal. Animal passive. Electrode: ant. med. cere. gangl. The record shows irregular throws of 6 and 7 mm. amplitude. Type 13 (1).

Record 20. Shined flashlight into right eye of animal. Animal passive. Electrode: post. med. cere. gangl. The record shows irregular throws of 5 and 6 mm. amplitude. Type 13 (1).

Record 21. Sounded 325 d.v. tuning fork into right side of animal. Animal passive. Electrode: post. med. cere. gangl. The record shows a long series of regular throws of 10 mm. amplitude. Type 7 (2).

Record 22. Sounded 325 d.v. tuning fork on right side of animal. Animal passive. Electrode: ant. med. cere. gangl. The record shows a fairly long series of 13 mm. amplitude throws. Type 9 (2).

Record 23. Hit animal's left pincher with pencil. Animal winced. Electrode: post. med. cere. gangl. The record shows a long regular series of 10 mm. throws. Type 7 (2).

Record 24. Animal spontaneously moving slightly. Electrode: post. med. cere. gangl. The record shows a fairly long series of 11 mm. throws. Type 9 (2).

Record 25. Animal spontaneously moving slightly. Electrode: ant. med. cere. gangl. The record shows several short series of 10 mm. throws. Type 8 (2).

Record 26. Animal spontaneously moving slightly. Electrode: ant. med. cere. gangl. The record shows two quite long series which reach 12 mm. in amplitude. Type 9 (2).

Crayfish L April 16, 1933, 9:00 p.m.

Description of Records:

Record 1. Closed circuit. The record is negative. Type 1 (0).

Record 2. Open circuit. The record is quite regularly 'fuzzy'.

Record 3. The animal was passive in the room light. Electrode: left ant. lat. cere. gangl. The record shows irregular activity of 7 and 8 mm. amplitude. Type 13 (1).

Record 4. Animal passive in the room light. Electrode: ant. med. cere. gangl. The record shows irregular activity of 7 and 8 mm. amplitude. Type 13 (1).

Record 5. Hit animal's back with pencil. Animal moved slightly. Electrode: ant. med. cere. gangl. There is a fairly long irregular series of 10 mm. throws on the record. Type 9 (2).

Record 6. Hit animal's back with pencil. Animal moved slightly. Electrode: left ant. lat. cere. gangl. There is a fairly long series of 10 mm. throws at the first of the record. Type 9 (2).

Record 7. Animal spontaneously moved left claw. Electrode: left ant. lat. cere. gangl. The record shows a very long series of 10 mm. throws. Type 7 (2).

Record 8. Animal spontaneously moved left claw. Electrode: ant. med. cere. gangl. The record shows two short series of 9 mm. throws, one at the first of the record and one just after the center of the record. Type 8 (2).

Record 9. (no record: error in numbering.)

Record 10. Animal passive in the dark. Electrode: ant. med. cere. gangl. The record shows irregular throws of 7 and 8 mm. amplitude through the record. Type 13 (1).

Record 11. Animal passive in the dark. Electrode: left ant. lat. cere. gangl. The record is negative. Type 1 (0).

Record 12. Punched animal's right eye with pencil. Animal passive. Electrode: left ant. lat. cere. gangl. The record shows two fairly long series of 10 mm. throws. Type 9 (2).

Record 13. Punched animal's right eye with pencil. Animal passive. Electrode: ant. med. cere. gangl. The first part of the record shows small irregular activity. In the center of the record there is a fairly long series which reaches 20 mm. in amplitude and tapers off gradually. Type 5 (4).

Record 14. Punched animal's pincher with pencil. Animal winced. Electrode: ant. med. cere. gangl. The record starts with irregular activity. At the end of the first third there is a short series which reaches 17 mm. in amplitude. At the very end of the record there is a short 10 mm. series. Type 4 (4).

Record 15. Animal passive in the room light. Electrode: left post. lat. cere. gangl. The record shows a long regular series

of 11 mm. throws. This series extends for thee fourths of the record. Type 7 (2).

Record 16. Animal passive in the room light. Electrode: rt. post. lat. cere. gangl. The record is negative. Type 1 (0).

Record 17. Punched animal's back with pencil. Animal winced. Electrode: rt. post. lat. cere. gangl. The record shows six short series fairly equally spaced in the record which reach 12 mm. in amplitude. Type 8 (2).

Record 18. Animal moved legs spontaneously, slightly. Electrode: rt. post. lat. cere. gangl. The record is negative. Type 1 (0).

Record 19. Punched animal's leg with pencil. Animal winced. Electrode: left post. lat. cere. gangl. The record shows four short 10 mm. amplitude series equally spaced throughout the record. Type 8 (2).

Record 20. Punched animal's leg with pencil. Animal winced. Electrode: left post. lat. cere. gangl. The first third of the record shows small irregular activity. At the beginning of the second third there is a long series which starts gradually and reaches 20 mm. in amplitude. Type 5 (4).

Record 21. Closed circuit. The record is entirely negative. Type 1 (0).

Record 22. Animal moved legs slightly spontaneously. Electrode: rt. post. lat. cere. gangl. The record shows regular activity of 5 and 6 mm. amplitude. Type 12 (1).

Record 23. Animal moved legs slightly, spontaneously. Electrode: rt. post. lat. cere. gangl. There are small 6 and 7 mm. throws, regular, throughout the record. Type 12 (1).

Record 24. Animal walked spontaneously. Electrode: rt. post. lat. cere. gangl. The record shows regular 5 and 6 mm. activity. Type 12 (1).

Record 25. Animal walked spontaneously. Electrode: left post. lat. cere. gangl. The record shows regular throws throughout of 5 and 6 mm. amplitude. Type 12 (1).

Record 26. Animal walked spontaneously. Electrode: left post. lat. cere. gangl. The record is negative. Type 1 (0).

Record 27. Animal passive in the room light. Electrode: left post. lat. cere. gangl. The record is negative. Type 1 (0).

Record 28. Animal passive in the room light. Electrode: rt. post. lat. cere. gangl. The record is negative. Type 1 (0).

Record 29. Punched animal's back six times with pencil. Animal winced slightly. Electrode: rt. post. lat. cere. gangl. The record shows six short series which are very much alike and equally spaced through the record. These series reach 16 mm. in amplitude. They are fairly abrupt in onset, but taper off more gradually. Type 4 (4).

Record 30. Punched animal's back three times with pencil. Animal winced very slightly. Electrode: left post. lat. cere. gangl. There are three short equally spaced series in the record which reach 10 mm. in amplitude. Type 8 (2).

Record 31. Animal walked spontaneously. Electrode: left post. lat. cere. gangl. There is a short series of 10 mm. throws in the center of the record as well as small irregular activity in the rest of the record. Type 8 (2).

Record 32. Animal walked spontaneously. Electrode: rt. post. lat. cere. gangl. The record is irregularly active throughout with throws which reach 16 mm. in amplitude. Type 11 (4) minus.

Record 33. Animal walked spontaneously. Electrode: rt. post. lat. cere. gangl. The record commences with small irregular activity. In the center of the record there is a long series which reaches 12 mm. in amplitude. Type 9 (2).

Record 34. Shined flashlight into right eye of animal. Electrode: rt. post. lat. cere. gangl. The record shows uniform small activity of 6 and 7 mm. throughout the record. Type 12 (1).

Record 35. Shined flashlight into right eye of animal. Electrode: left post. lat. cere. gangl. The record shows throws of 5 and 6 mm. amplitude scattered through the record. Type 13 (1).

Record 36. Animal walked spontaneously. Electrode: left post. lat. cere. gangl. The first half of the record shows irregular small activity. In the last half of the record there is a fairly long series which reaches 10 mm. amplitude and is very irregular. Type 9 (2).

Record 37. Animal walked spontaneously. Electrode: rt. post. lat. cere. gangl. The record begins with a fairly long, but irregular series of 10 mm. amplitude. The remainder of the record shows irregular small activity. Type 9 (2).

Record 38. Sounded 325 d.v. tuning fork on right side of animal. Animal passive. Electrode: left post. lat. cere. gangl. The record shows irregular scattered throws of 6 and 7 mm. amplitude. Type 13 (1).

Record 39. Sounded 325 d.v. tuning fork on right side of animal. Animal passive. Electrode: rt. post. lat. cere. gangl. There are irregular throws of 5 and 6 mm. amplitude scattered

through the record. Type 13 (1).

Record 40. Sounded 325 d.v. tuning fork on right side of animal when animal was walking spontaneously. Electrode: rt. post. lat. cere. gangl. The record shows a long series of regular throws which reach 9 mm. in amplitude. Type 7 (2).

Record 41. Sounded 325 d.v. tuning fork on right side of animal when animal was walking spontaneously. Electrode: left post. lat. cere. gang. There are throws of 5 and 6 mm. amplitude scattered through the record irregularly. Type 13 (1).

Crayfish N April 23, 1933, 8:30 p.m.

Description of Record:

Record 1. Closed circuit. The record is negative. Type 1 (0).

Record 2. Animal passive in the dark. Electrode: rt. post. lat. cere. gangl. The record is negative. Type 1 (0).

Record 3. Animal passive in the dark. Electrode: ant. med. cere. gangl. The record is negative. Type 1 (0).

Record 4. Shined flashlight into right eye of animal. Electrode: ant. med. cere. gangl. The record is negative. Type 1 (0).

Record 5. Shined flashlight into right eye of animal. Animal passive. Electrode: rt. post. lat. cere. gangl. The record is negative. Type 1 (0).

Record 6. Animal spontaneously walking. Electrode: rt. post. lat. cere. gangl. The record shows a few scattered throws of 5 and 6 mm. amplitude. Type 13 (1).

Record 7. Animal spontaneously walking. Electrode: ant. med. cere. gangl. The record is negative. Type 1 (0).

Record 8. Animal passive in the dark. Electrode: rt. ant. lat. cere. gangl. The record is negative. Type 1 (0).

Record 9. Animal passive in the dark. Electrode: left post. lat. cere. gangl. The record is negative. Type 1 (0).

Record 10. Animal passive in the dark. Electrode: left post. lat. cere. gangl. The record is negative. Type 1 (0).

Record 11. Animal passive in the dark. Electrode: rt. ant. lat. cere. gangl. The record is negative. Type 1 (0).

Record 12. Shined light into right eye of animal. Animal passive. Electrode: rt. ant. lat. cere. gangl. The record is negative. Type 1 (0).

Record 13. Shined light into right eye of animal. Animal passive. Electrode: left post. lat. cere. gangl. The record shows irregular throws of 5 and 6 mm. amplitude. Type 13 (1).

Record 14. Animal passive in the dark. Electrode: rt. post. lat. cere. gangl. The record shows scattered throws of 5 and 6 mm. amplitude. Type 13 (1).

Record 15. Animal passive in the dark. Electrode: left post. lat. cere. gangl. The record is negative. Type 1 (0).

Record 16. Shined flashlight into right eye of animal. Animal passive. Electrode: left post. lat. cere. gangl. The record is negative. Type 1 (0).

Record 17. Shined flashlight into right eye of animal. Animal passive. Electrode: rt. post. lat. cere. gangl. The record shows scattered throws of 7 and 8 mm. amplitude particularly toward the last of the record. Type 13 (1).

Record 18. Rubbed pencil on head of animal. Animal fairly passive. Electrode: rt. post. lat. cere. gangl. The record shows several short series of throws which reach 10 mm. in amplitude. Type 8 (2).

Record 19. Rubbed head of animal with pencil. Animal winced, slightly. Electrode: left post. lat. cere. gangl. The record shows three short series in the last half of the record which reach 30 mm. in amplitude. Type 4 (4).

Record 20. Animal wriggled slightly spontaneously. Electrode: left post. lat. cere. gangl. There are irregular throws of 5 and 6 mm. scattered through the record. Type 13 (1).

Record 21. Animal wriggled slightly, spontaneously. Electrode: rt. post. lat. cere. gangl. There is a fairly long irregular series in the last third of the record which reaches 12 mm. in amplitude. Type 9 (2).

Record 22. Sounded 325 d.v. tuning fork on right side of animal. Animal passive. Electrode: rt. post. lat. cere. gangl. The record is negative. Type 1 (0).

Record 23. Animal wriggled spontaneously, slightly. Electrode: rt. post. lat. cere. gangl. The record is negative. Type 1 (0).

Record 24. Sounded 325 d.v. tuning fork on right side of animal. Animal passive. Electrode: left post. lat. cere. gangl. The record is negative. Type 1 (0).

Record 25. Animal wriggled spontaneously. Electrode: post. med. cere. gangl. The record shows a short series at the end of the first third of the record which reaches 10 mm. Type 8 (2).

Record 26. Animal wriggled spontaneously. Electrode: ant. med. cere. gangl. The record shows irregular throws of 5 and 6 mm. throughout. Type 13 (1).

Record 27. Animal wriggled spontaneously. Electrode: ant. med. cere. gangl. The record shows several short series which reach 10 mm. in amplitude. Type 8 (2).

Record 28. Animal wriggled spontaneously. Electrode: ant. med. cere. gangl. There are scattered throws of 5 and 6 mm. throughout the record. Type 13 (1).

Record 29. Punched animal's tail with pencil. Animal wriggled. Electrode: post. med. cere. gangl. The record shows irregular activity of 5 and 6 mm. throughout. Type 13 (1).

Record 30. Punched animal's tail with pencil. Animal wriggled. Electrode: post. med. cere. gangl. The record shows a short series of 9 mm. throws at the first of the record. Type 8 (2).

Record 31. Punched animal's tail with pencil. Animal wriggled. Electrode: post. med. cere. gangl. The record shows extended activity which reaches 40 mm. in amplitude. The record is irregular. At the end of the record there is a slow throw which may be electrode movement. Type 11 (4).

(2). Relation Between Stimulus-Response Situations and Records - The reports just described contain three variables: the stimulus, the response of the animal, and the electrode position. In order to present the results of these variables in as concise a form as possible, the records will be grouped according to the stimulus-response condition and the architectural region. From the 121 records obtained on the crayfish there were 11 stimulus-response situations with sufficient area of distribution on the brain to be significant. Descriptions of these follow, along with a figure of the animal's brain showing the positions and the relative amplitude of the records on a given area. Shading indicates the extent of activity of the various regions, that is, the darker the shading the greater the area was involved in the particular stimulus-response

situation. This method was modified after Bartley (6) and Perkins (31).

The visual and olfactory paths of the crustacean brain have been described by Kappers (26) and Hanström (20). The so-called visual regions include the anterior right and left protocerebrum. The olfactory regions include the anterior and posterior olfactory lobe. The anterior and posterior deutocerebrum are described as association centers (Hanström). The right and left tritocerebrum appears to be motor in function (Hanström). The motor 'areas' do not seem to be well known, however.

In the description that follows, the brain of the crayfish is divided for convenience into six regions, already mentioned. As these same names are used in the following tables, their supposed function is here indicated. The anterior medial cerebral ganglion is said to be association and visual in function; the left anterior lateral cerebral ganglion, visual and olfactory in function; the right anterior lateral cerebral ganglion, visual and olfactory; the left posterior lateral cerebral ganglion, olfactory and motor; the right posterior lateral cerebral ganglion, olfactory and motor; and the posterior medial cerebral ganglion, association and motor. These assertions are taken from Kappers (26) and Hanström (20).

(a). Animal Passive in the Room Light. The first behavior situation to be considered is that of the animal passive in ordinary room illumination. Table I shows the regions of the brain, the types of records obtained, and their average amplitude.

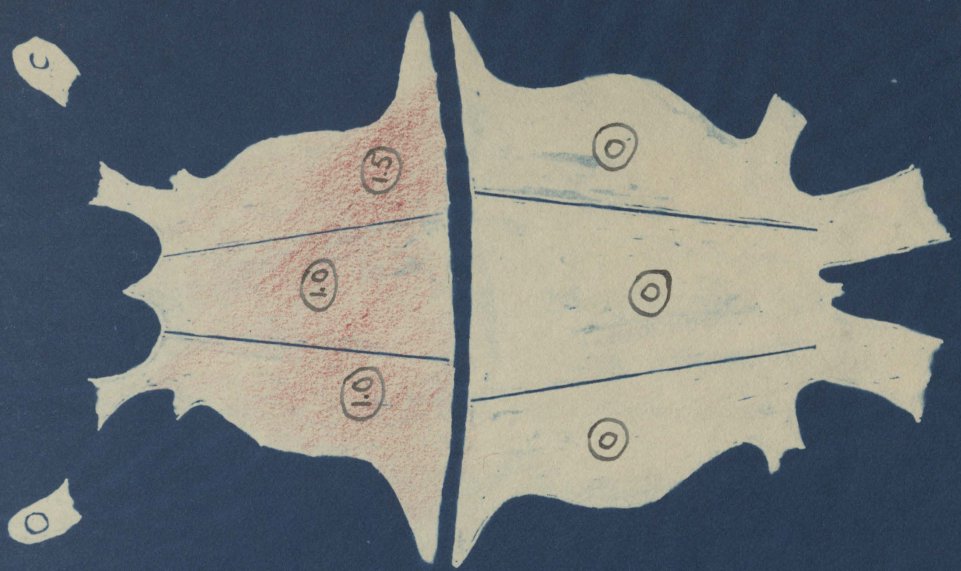

fig. 1

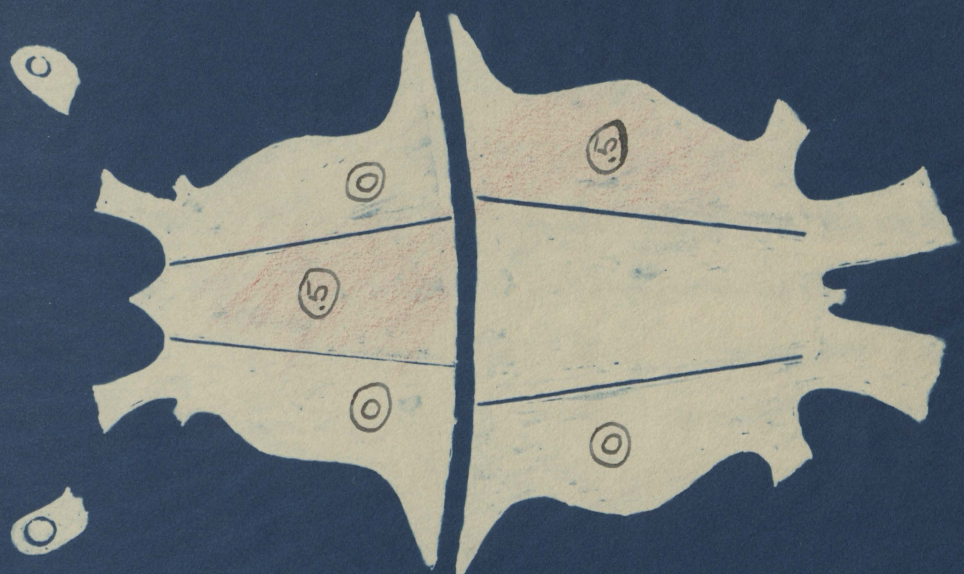

fig. 2

PLATE IV

Table I

Brain Position	Record Type	Average Magnitude
Ant. med. cere. gangl.	1, 13,7	1.0
Lft. ant. lat. cere. gangl.	9, 1, 13	1.0
Rt. ant. lat. cere. gangl.	9, 1	1.5
Lft. post. lat. cere. gangl.	1	0
Rt. post. lat. cere. gangl.	1, 1	0
Post. med. cere. gangl.	1	0
	12 records	Average .58

The data are shown pictorially in the following map (Plate IV, figure 1). Circles indicate the positions of the electrodes and the number indicates the average magnitude of throws for that region as given in the third column of Table I. The shading represents the relative magnitude of neural activity, the darker the shading the more highly active the area. It will be noted from an examination of the map that the forward half of the animal's brain is slightly active, whereas the posterior half is entirely passive. The point of greatest cerebral activity occurs on the right side in the so-called visual and olfactory region. The 'association' and the rest of the 'visual' and 'olfactory' regions are slightly less active. The 'motor' portion of the brain is totally negative. In Table I, for purposes of comparison, the average amplitude value for the entire brain has been computed and is .58.

(b). Animal Passive in the Dark. The next behavior situation is that of the animal passive in the dark, which was merely the absence of the room illumination. The results of this situation are presented in Table II, in which the first column gives the electrode position, the second the

types of records, and the third the average magnitude of the records. At the bottom of the table is given the total average magnitude for this situation.

Table II

Brain Position	Record Type	Average Magnitude
Ant. med. cere. gangl.	1, 13	.5
Lft. ant. lat. cere. gangl.	1	0
Rt. ant. lat. cere. gangl.	1, 1	0
Lft. post. lat. cere. gangl.	1, 1, 1	0
Rt. post. lat. cere. gangl.	1, 13	.5
	10 records	Average .20

The data from Table II have been plotted on a map (Plate IV, figure 2) of the animal's brain, giving the relative average amplitude in the circles on the areas and shaded darkest where the most activity occurred. It will be noted from examination of this map that there are only two regions which exhibit any activity under this condition and that these are only very slightly active. These regions are the 'olfactory', the 'association' and part of the 'motor' region. In the condition of room light and the animal passive there was an anterior gradient whereas under no light and the animal passive there is a very low-amplitude, diagonal gradient. The map shows that the 'visual' regions are negative. The average magnitude of all the records taken under this stimulus condition was .20 which is less than half of that on the condition of room light and animal passive.

(c). Animal Passive with Flashlight in Eye. This behavior situation consisted of a hand flashlight shined into the animal's eye, while the animal remained passive. The results of this

group of data are shown in Table III.

Table III

Brain Position	Record Type	Average Magnitude
Ant. Med. cere. gangl.	13, 1	.5
Lft. ant. lat. cere. gangl.	11	4.0
Rt. ant. lat. cere. gangl.	8, 1	1.0
Lft. post. lat. cere. gangl.	13, 1, 13	.66
Rt. post. lat. cere. gangl.	1, 1, 12	.33
Post. med. cere. gangl.	13	1.0
	12 records	Average 1.24

The data from Table III are shown in Plate V, figure 1. The map shows a definite peak in the left visual and olfactory region. The corresponding right region is slightly active, but more so than any other except the motor and association area on the posterior end. The other three regions are very slightly active. This high-peaked, steep gradient is in contrast with, but in many ways similar to, the gradient set up when only the room light is turned on. There is a definite raising of the level of activity, but the relationships are much the same. The average magnitude for all the records taken under this condition was 1.24, as compared with .58 under room light and .20 with the animal in the dark.

Note that in Plate V, figure 1 the greatest activity appears on the left side when the stimulus was applied to the right eye.

(d). Animal Passive When Leg or Back was Hit. The next behavior situation to be considered is that of animal passive when the experimenter hit the animal's leg or back with a pencil. The data from this group are presented in Table IV.

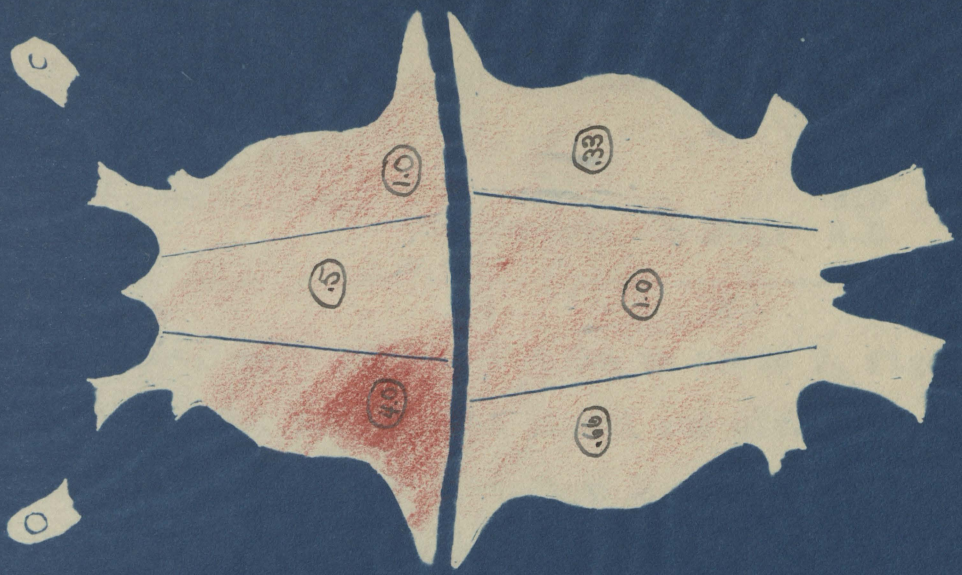

fig. 1.

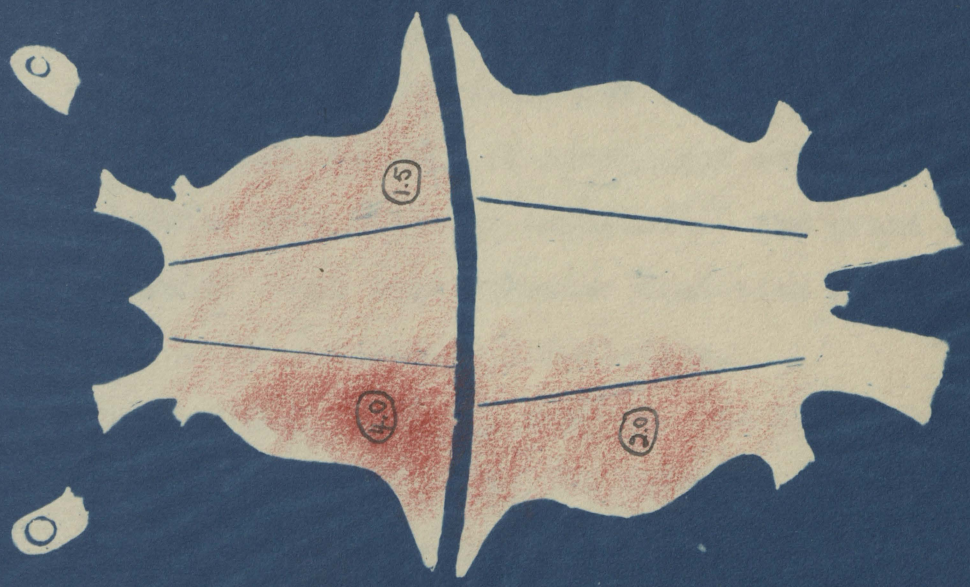

fig. 2

PLATE V

Table IV

Brain Position	Record Type		Average Magnitude
Lft. ant. lat. cere. gangl.	2		4.0
Rt. ant. lat. cere. gangl.	13, 9		1.5
Rt. post. lat. cere. gangl.	8		2.0
	4 records	Average	2.5

The data from this table are shown in Plate V, figure 2. The map shows a large peak in the visual and olfactory region as did the last plate, under flashlight conditions. In this case, however other regions explored are larger in amplitude. The olfactory-and-motor region shows medium activity and the visual-and-olfactory region shows slight activity. All of the brain was not explored in this case, but the regions explored show a similar gradient to that of flashlight stimulation except that the motor area rises in amplitude. The grand average for the records under this behavior condition is 2.5 as compared with 1.24 under flashlight stimulation.

(e). Animal Passive with Eye Punched. In this behavior situation the experimenter punched the animal's eye with a pencil. The data are shown in Table V. They are not complete since the posterior portion of the brain was not explored.

Table V.

Brain Position	Record Type		Average Magnitude
Ant. med. cere. gangl.	5		4.0
Lft. ant. lat. cere. gangl.	8, 9		2.0
Rt. ant. lat. cere. gangl.	1		0
	4 records	Average	2.0

The data from Table V are given in Plate VI, figure 1.

There is a definite peak in the visual and association region, in the anterior half of the brain. There is slight activity in the visual and olfactory region on the left side. The corresponding region on the right side is negative. Since no records were obtained from the posterior half of the brain the results regarding this situation cannot be considered conclusive. They do indicate a trend, however, in the form of a gradient which differs slightly from that with the animal passive upon being hit on back or leg. There is a slight shift. in the peak toward the center of the anterior portion of the brain. The average magnitude for all the records in this case is 2.0, which is less than in situation (d), but compares rather favorably with it.

(f). Animal Moved or Winced When Hit Leg or Claw. The behavior situations with the crayfish, so far, have been with the animal passive. This situation begins a series in which the animal made a definite response. In this case the animal moved or winced when the experimenter hit the animal's leg, pincher or claw. The data from this group are presented in Table VI.

Table VI.

Brain Position	Record Type		Average Magnitude
Ant. med. cere. gangl.	4		4.0
Lft. ant. lat. cere. gangl.	4, 4, 11		4.0
Rt. ant. lat. cere. gangl.	2, 1. 9		2.0
Lft. post. lat. cere. gangl.	8, 5		3.0
Rt. post. lat. cere. gangl.	11		4.0
Post. med. cere. gangl.	7		2.0
	LL records	Average	3.15

The data from the above table are shown in Plate VI, figure 2. The map shows three peaks of maximum amplitude which are located in the visual, association, olfactory and motor regions. The olfactory-and-motor region on the left side is active to a medium extent, as is the association-and-visual region. It will be noted that the anterior portion of the animal's brain is slightly more active than the posterior and that the whole level of activity has been raised above that of the animal passive with motor stimulation. The gross average for this condition is 3.15 as compared with 2.5 when the animal's leg or back was hit (passive), or 2.0 when the animal remained passive to punching of the eye.

(g). Animal Raised Body or Winced When Back, Head, or Tail Was Hit. The next situation in which the animal was active was when the animal raised its body or winced when hit, by the experimenter, on the head, back, or tail, with the pencil. See Table VII.

Table VII.

Brain Position	Record Type	Average Magnitude
Ant. med. cere. gangl.	9	2.0
Lft. ant. lat. cere. gangl.	12,11,2,12,11,12,9	2.42
Rt. ant. lat. cere. gangl.	9,11,2	3.3
Lft. post. lat. cere. gangl.	4,8	3.0
Rt. post. lat. cere. gangl.	8,4	3.0
Post. med. cere. gangl.	13,8,11	2.3
	18 records Average	2.62

The data from Table VII are shown in Plate VII, figure 1. The right visual-and-olfactory region shows the highest peak, although the two motor-and-olfactory regions, in the posterior

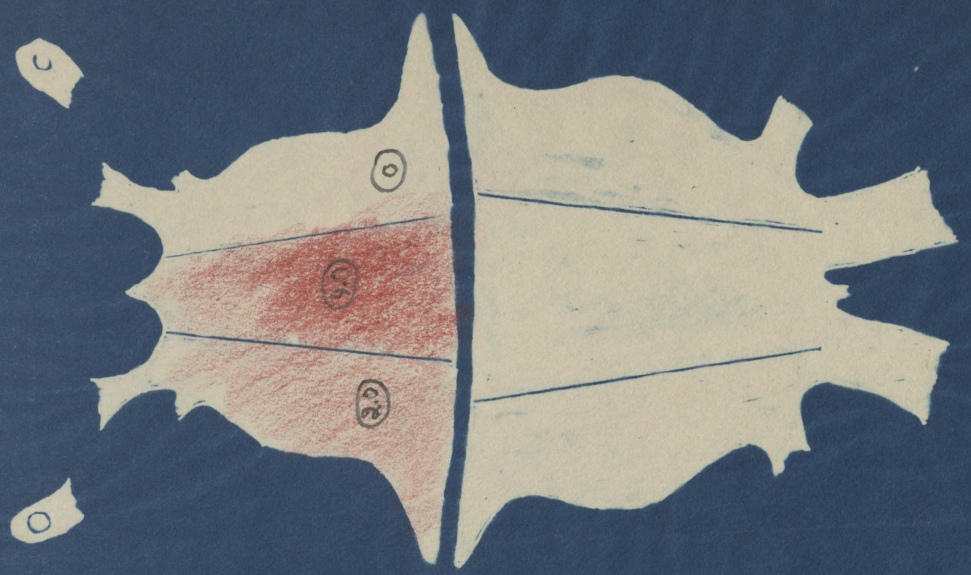

fig. 1

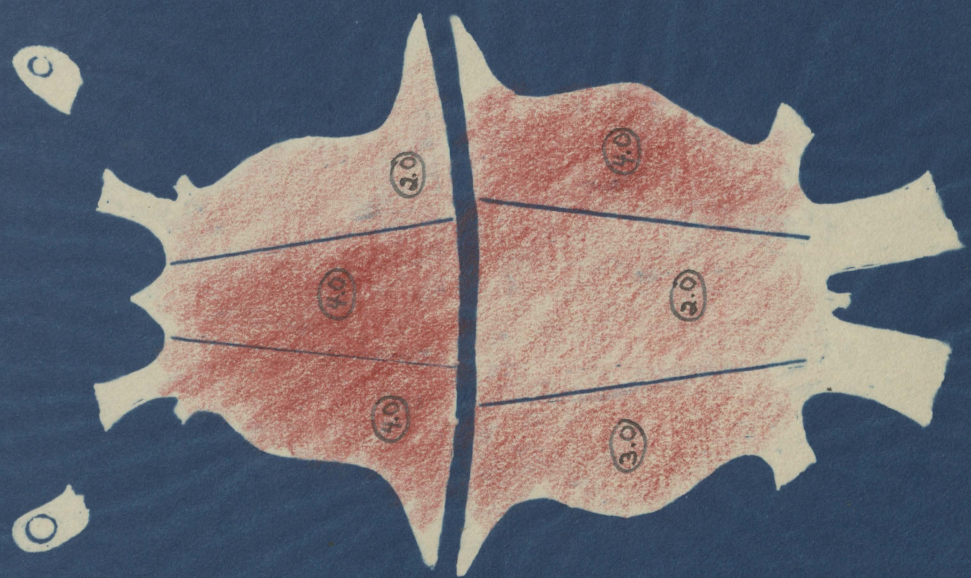

fig. 2

PLATE VI

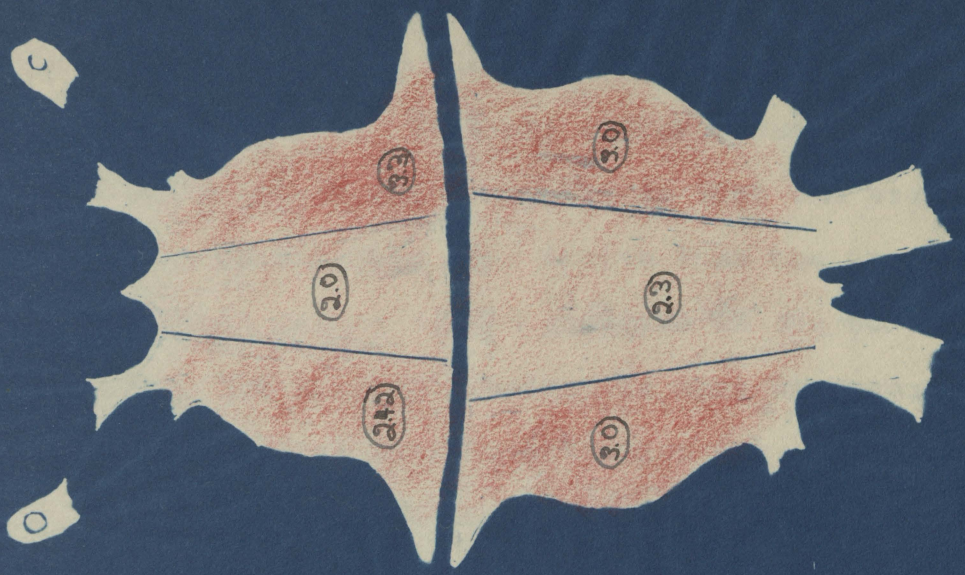

fig. 1

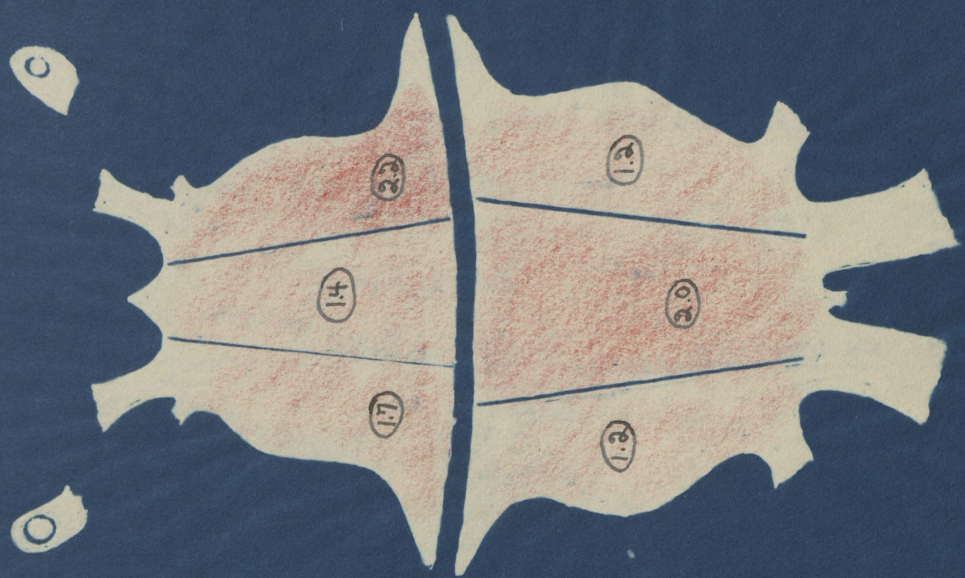

fig. 2

PLATE VII

half of the brain, are about the same magnitude. All of these are fairly active. Slightly lower are the association-and-motor, and visual regions. This map differs from the one where the animal's leg or claw were hit in that the posterior half of the brain is slightly more active than the anterior, although the general nature of the gradient in the two cases is very similar. The present gradient is more homogeneous and is a slightly lower level then in situation (f). The average magnitude for all the records in this case is 2.65 while it was 3.15 under (f) and 2.5 under (d) with the animal passive.

(h). Animal Spontaneously Moving or Walking. In this behavior situation the animal was making spontaneous responses, either of movement of claws and feet, or, actually walking on the operating table. See Table VIII.

Table VIII.

Brain Position	Record Type	Average Magnitude
Ant.med. cere gangl.	8,9,1,13,8,13,8	1.4
Lft. ant. lat. cere. gangl.	12,7,7,7	1.7
Rt. ant. lat. cere. gangl.	12,8,8,5	2.2
Lft. post. lat. cere. gangl.	13,12,1,8,9	1.2
Rt. post. lat. cere. gangl.	1,9,1,1,12,12,12,11-,9,9	1.2
Post. med. cere. gangl.	9,8	2.0
	32 records Average	1.61

The data from the above table are plotted in a map of the Plate VII, figure 2. It will be noted at once that the gradient in this case is reduced in amplitude and that its general contour is diagonal from the visual-and-olfactory region in the anterior half of the brain to the association-and-motor region in the posterior half of the brain. Both of

these peaked regions are, however, only medium in amplitude. The other regions of the brain are for the most part homogeneously active at a slight amplitude. The gross average under this condition is only 1.61 as compared to 2.65 under (g) and 3.15 under (f). The amplitude of 2.5 under (d) with the animal passive exceeds the magnitude under the present behavior condition.

(i). Animal Passive When 325 d.v. Fork was Sounded. This behavior situation is the first of the group which involves auditory stimuli. In this case the animal was stimulated with a 325 d.v. tuning fork to which the animal was passive. See Table IX.

Table IX.

Brain Position	Record Type	Average Magnitude
Ant. med. cere. gangl.	9	2.0
Lft. ant. lat. cere. gangl.	7	2.0
Rt. ant. lat. cere. gangl.	5	4.0
Lft. post. lat. cere. gangl.	1,13	.5
Rt. post. lat. cere. gangl.	1,13	.5
Post. med. cere. gangl.	7	2.0
	8 records	Average 1.83

The data from Table IX have been transferred to Plate VIII, figure 1. The map shows a definite peak in the visual-and-olfactory region, which reaches a maximum on our evaluation scale. In general the gradient is highest in the anterior half of the animal's brain. It is not known, apparently, where the 'auditory' pathways and area are in the crayfish. The activity of medium amplitude included the visual, association,

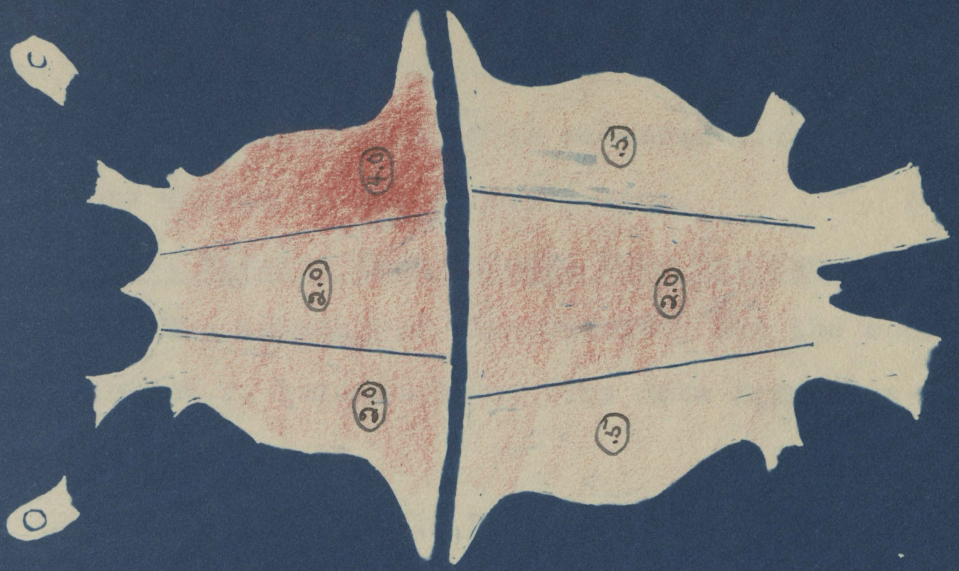

fig. 1

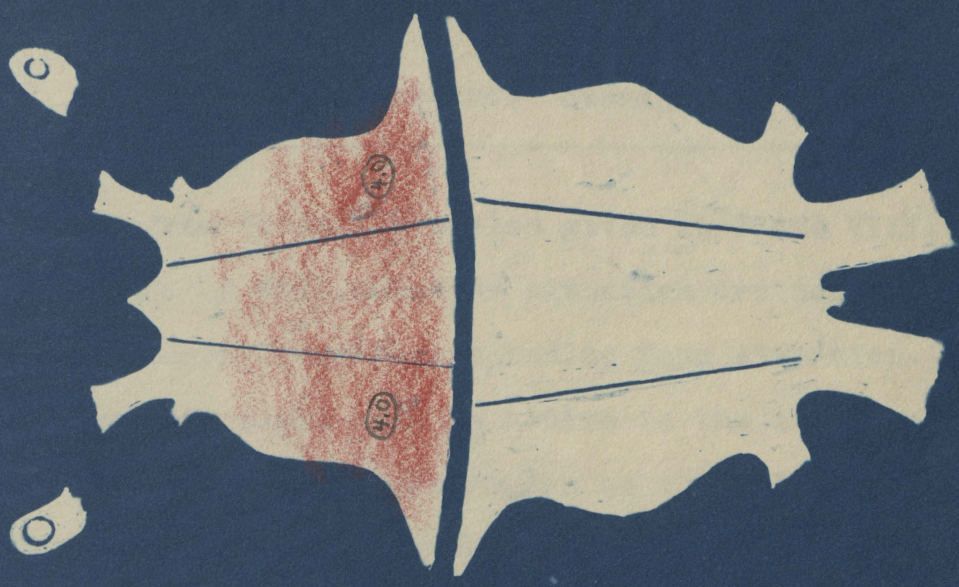

fig. 2

PLATE VIII

and part of the olfactory-and-motor regions. It is noteworthy that most of the motor region is nearly negative. The average for the entire situation is 1.83 as compared with 1.24 with the flashlight shined in the animal's eyes.

(j). Animal Passive When Quincke Tube Was Sounded. In this situation the animal was also passive, but the sound stimulus was a 1024 d.v. quincke tube. The data from this situation are shown in Table X.

Table X.

Brain Position	Record Type	Average Magnitude
Lft. ant. lat. cere. gangl.	11	4.0
Rt. ant. lat. cere. gangl.	11	4.0
	2 records	Average 4.0

The data from Table X are also given in Plate VIII, figure 2. The data in this behavior situation are incomplete, but show some resemblance to the tuning fork situation. The same region on the right side is active to the same extent, while the visual-and-olfactory region on the left side in this case active to a maximum. The map also suggests the same anterior gradient which appeared in case of the tuning fork. The gross average magnitude in this case is 4.0 (two records) as compared with 1.83 in the tuning fork situation.

(k). Animal Walking When 325 d.v. Fork Was Sounded. In this situation the animal was walking on the operating table while the 325 d.v. tuning fork was sounded by the experimenter. The data appear in Table XI.

Table XI.

Brain Position	Record Type	Average Magnitude
Lft. post. lat. cere. gangl.	13	1.0
Rt. post. lat. cere. gangl.	7	2.0
	2 records	Average 1.5

The data from the above table also appear in Plate IX, figure 1. The data are incomplete but seem significant when compared with the situation with the tuning fork and the animal passive. In the present case the posterior olfactory and motor regions take on slight or medium amplitude levels, whereas in the case of the animal passive these same regions were practically negative. The average in this case is 1.5 as compared with 1.83 with the animal passive, but the scarcity of data prohibits a serious comparison.

(3). Conclusions on the Crustacean. The data that have been presented on the crayfish may be summarized under five heads: light stimulation, tactual stimulation with the animal passive, tactual stimulation with the animal responding, spontaneous activity, and auditory stimulation.

(a). Light Stimulation. In (b), darkness and passive, it was found that a very low amplitude, diagonal gradient appeared in the olfactory, association and part of the motor regions. The average magnitude under this condition was only .20. When the animal was stimulated with the room light (a) the gradient became more extended in the anterior half of the brain. This anterior gradient was nearly homogeneous. The average magnitude in this case was .58. When the animal was

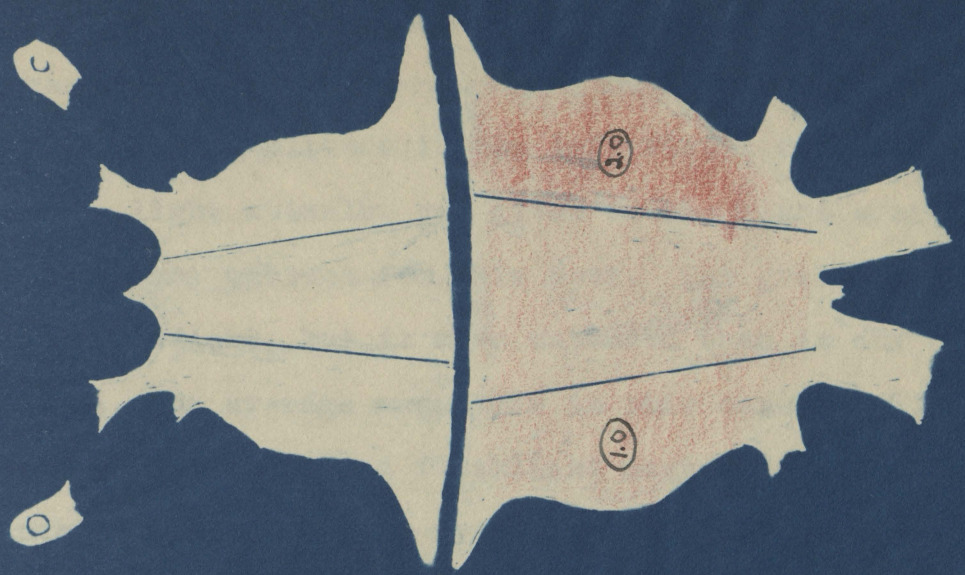

fig. 1

fig. 2

PLATE IX

given a definite visual stimulus, the flashlight, (c), the brain became considerably more active throughout, and shows a peak of maximum amplitude in the left visual and olfactory region. The light stimulus was given on the right eye of the animal, which may account for this peak. The gradient is still an anterior gradient, but is more extended than in any of the other cases. The average magnitude in this case was 1.24. Grouping the room light and flashlight magnitudes together, and comparing them, shows an average under light stimulation of .91 as compared with the .20 under darkness conditions.

(b). Passive With Tactual Stimulation. There were two situations under this group, (d) and (e), which show a definite raising of the level of the gradient with peaks for the most part in the anterior portion of the brain. This would be consistent with the sensory function of the anterior half as opposed to the motor function of the posterior half of the brain. The average magnitudes of the two situations are 2.5 and 2.0, respectively, which give an index to the general increase in the level of the gradient. The average of these two gives 2.25 as the magnitude value for motor stimulation with the animal passive.

(c). Animal Responded to Tactual Stimulation. There are two situations in this group, (f) and (g), with the animal moving or wincing. The first (f) in which the animal's leg or claw was hit, and the animal moved or winced, there are peaks in the visual, association, olfactory, and motor regions, of maximum amplitude. The extent and height of the gradient are greatly increased, but the anterior half of the brain is still

slightly more active than the posterior. The average magnitude for this situation is 3.15. In situation (g), where the animal's back or body was hit, and the animal winced or raised its body, the level of activity is not so great, but in this case the highest regions of activity are located in the posterior half of the brain. The average evaluation in this case is 2.62. The average of these two situations gives a value of 2.88 for the animal active as compared with the average of 2.25 with the animal passive under motor stimulation. The difference in gradients between the animal passive and active is that the extent of activity increases while at the same time there is a spreading of the activity to more regions. At the same time the posterior portion of the brain becomes relatively more active, where the motor regions are situated.

(d). Animal Spontaneously Walking. There is one situation, (h), in which the animal spontaneously walked on the operating table. The gradient in this case is not as high as in either of the situations of tactual stimulation, active or passive. This suggests that the tactual stimulation in the other cases was more intense, possibly painful. This theory would also be substantiated by the fact that the peaks in the other gradients were located in the general sensory region of the brain. With spontaneous movement there is a diagonal gradient from the visual and olfactory regions to the association and motor regions. This gradient would suggest that the animal was responding to visual, perhaps olfactory, stimuli (this is probably more important than vision in the crustacean) at the time it was mak-

ing its movements. The average magnitude of 1.61 is less than the 2.88 of tactual stimulation and response, or the 2.25 with the animal passive under tactual stimulation.

(e). Auditory Stimulation. There are two groups of situations with auditory stimuli, those with the animal passive, (i), (j), and one with the animal walking, (k). The situations with the animal passive show again the anterior gradient which appeared with the visual stimulation. In this case maximum peaks are found in the visual, and olfactory regions in the anterior half of the brain. Very slight activity is found in most of the motor region, although medium activity appears in the association-motor region. When the animal was moving under sound stimulation the motor regions in the posterior portion of the brain became moderately active. The average magnitude for the passive auditory situations is 2.91 as compared with .91 for the visual and 2.25 for tactual stimulation. The average of all the auditory situations is 2.44 and is less then the animal active to tactual stimulation, 2.88.

The data from the crayfish will be discussed further when a comparison is made with the other animal forms.

IV. THE AMPHIBIAN.

(1). Description of Experiments and Records - There were eleven experiments made on the frog, in which 336 records were taken. A description of each experiment and each record, with its classification, are given in the section that follows. The electrode positions will be indicated in each case. The reader is referred to Plate X which shows a diagram of the frog brain with the arbitrary regions specified which were used in keeping track of the electrodes. It will be noted that there are seventeen of these divisions. This diagram also shows circles which contain the letters of the experiments, marking the positions of the electrodes.

Frog A February 21, 1933 9:00 p.m.

Description of Records:

Record 1. Animal passive in the room light. Electrode: posterior rt. and lft. forebrain. The record is negative. Type 1 (0).

Record 2. Animal passive in the room light. Electrode: anterior rt. and lft. forebrain. The record is negative. Type 1 (0).

Record 3. Closed circuit. The record shows a negative baseline. Type 1 (0).

Record 4. Pulled cord attached to animal's hind legs. Animal passive. Electrode: posterior rt. ant. lft. forebrain. The record is negative. Type 1 (0).

Record 5. Pulled cord attached to animal's hind legs. Animal stiffened and tried to flex legs. Electrode: posterior rt. and lft. forebrain. The record shows an extended series at the outset of 16 mm. amplitude. This series is uniform. The last third of the record is quiet. Type 10 (4).

Record 6. Animal passive in the room light. Electrode: rt. mid. tectum. The record is negative. Type 1 (0).

Record 7. Pulled cord attached to animal's legs. Animal stiffened and tried to flex legs. Electrode: rt. mid. tectum.

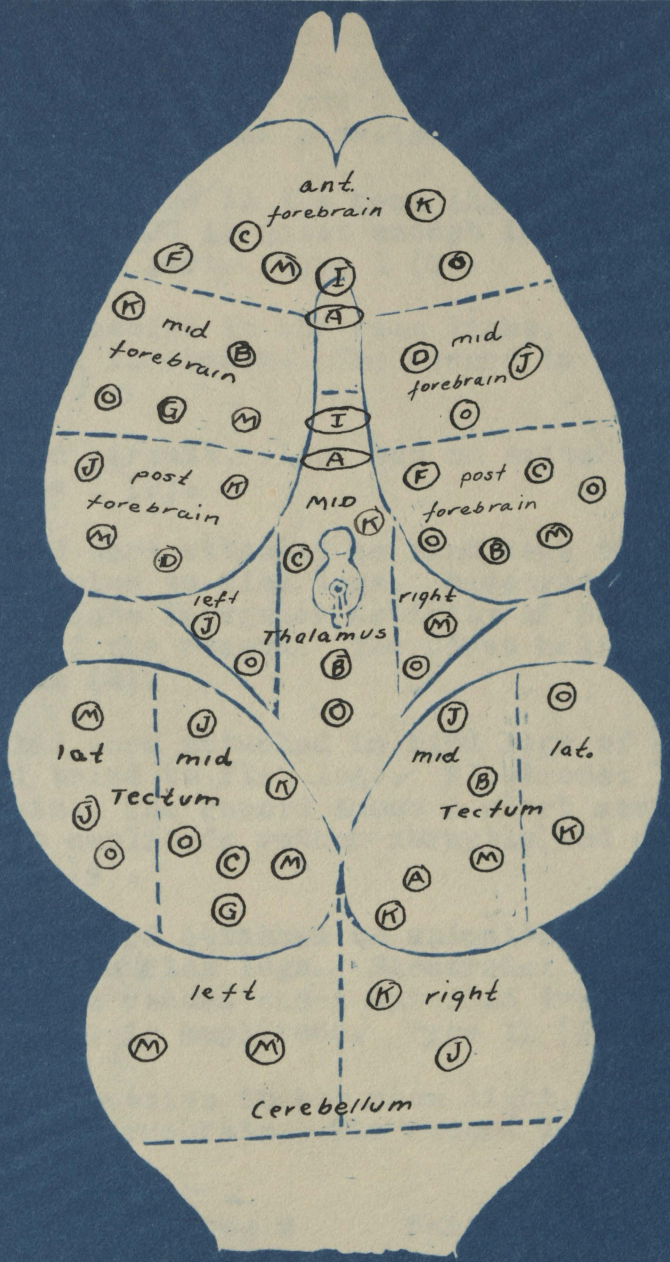
ant.
forebrain
mid
forebrain
mid
forebrain
post
forebrain
MID
post
forebrain
left
right
Thalamus
lat
mid
Tectum
mid
lat.
Tectum
left
right
Cerebellum

PLATE X

The first 100 mm. of the record are quiet. At the beginning of the next section there starts gradually a series which reaches 18 mm. in amplitude and lasts until nearly the end of the record where it subsides to the baseline. Type 11 (4).

Record 8. Animal passive in the room light. Electrode: rt. mid. tectum. The record is quiet except for spurious throws in the first and last part. Type 1 (0).

Record 9. Animal passive in the room light. Electrode: anterior rt. and lft. forebrain. The record is entirely negative. Type 1 (0).

Record 10. Closed circuit. Last tap on switch. The record is negative. Type 1 (0).

Record 11. Pulled cord attached to hind legs of animal. Animal resisted and tried to flex legs. Electrode: rt. mid. tectum. The record shows irregular activity of 30 mm. amplitude in the last half of the record. The first half of the record is quiet. Type 11 (4).

Record 12. Pulled cord attached to hind legs of animal. Animal resisted and tried to flex legs. Electrode: anterior rt. and lft. forebrain. The record shows a short series which reaches 20 mm. in amplitude rather abruptly and ends rather abruptly. Type 4 (4).

Record 13. Pulled cord attached to animal's hind legs. Animal resisted and tried to flex legs. Electrode: posterior rt. and lft. forebrain. The record shows extended irregular activity which reaches 25 mm. in amplitude. Type 11 (4).

Record 14. Animal passive in the room light. Electrode: posterior rt. and lft. forebrain. The record is entirely negative. Type 1 (0).

Frog B March 4, 1933 11:00 a.m. and 2:00 p.m.

Description of Records:

Record 1. Animal passive in the dark. Electrode: left middle forebrain. The record is negative with a quite steady baseline. Type 1 (0).

Record 2. Animal passive in the dark. Electrode: rt. posterior forebrain. The record is negative. Type 1 (0).

Record 3. Open circuit. The record is 'fuzzy' but at low amplitude.

Record 4. Hit animal's right leg with pencil. Animal winced: Electrode: left middle forebrain. The first 100 mm. of the

record are quiet. At this point there occurs a series which reaches 20 mm. in amplitude. Type 5 (4).

Record 5. Hit animal's right leg with pencil. Animal winced and struggled. Electrode: right posterior forebrain. The record commences with a series which extends for the length of the record and reaches 35 mm. in amplitude. The series is irregular. Type 11 (4).

Record 6. Pinched animal's leg. Animal struggled vigorously. Electrode: right posterior forebrain. The record commences with a series which lasts until the end of the record. This series is regular at a 25 to 35 mm. level. Type 10 (4).

Record 7. Pinched animal's leg. Animal struggled. Electrode: left middle forebrain. The first half of the record is fairly quiet. At the beginning of the second half there is a fairly long series which reaches 17 mm. in amplitude. Type 5 (4).

Record 8. Pushed rt. gastromemius muscles with glass seeker. Animal passive. Electrode: left forebrain. The first half of the record is quiet. In the second half there is a fairly long series which reaches 10 mm. in amplitude. Type 9 (2).

Record 9. Pushed left gastro. muscle with glass seeker. Animal passive. Electrode: left middle forebrain. The record shows long series of 10 mm. amplitude throughout the record. Type 9 (2).

Record 10. Pushed rt. gastro. muscle with glass seeker. Animal winced slightly. Electrode: rt. posterior forebrain. The first 20 mm. of the record are slightly active. At this point there starts fairly abruptly a series which reaches 20 to 25 mm. in amplitude and lasts to the end of the record. The series is regular. Type 10 (4).

Record 11. Pushed left gastro. muscle with glass seeker. Animal winced slightly. Electrode: right posterior forebrain. The first 100 mm. of the record are negative. At the beginning of the next section there is a fairly abrupt series which is irregular and reaches 40 mm. in amplitude. This series lasted to the end of the record. Type 11 (4).

Record 12. Hit animal's back with glass seeker. Animal winced slightly. Electrode: right posterior forebrain. The record is quiet for 50 mm. At this point there is an abrupt series which reaches 18 mm. in amplitude. The record is then irregularly active until midway when a longer series occurs which reaches 25 mm. in amplitude. Type 5 (4).

Record 13. Shined match into right eye of animal. Animal passive. Electrode: right posterior forebrain. The record shows scattered throws of 6 and 7 mm. throughout the record. Type 13 (1).

Record 14. Punched right eye with pencil. Animal blinked. Electrode: right posterior forebrain. The record starts with a series which reaches 30 mm. amplitude and then gradually tapers off into small activity. Type 5 (4).

Record 15. Punched left eye with pencil. Animal blinked. Electrode:lft. mid. forebrain. The record shows several short series which reach 10 mm. in amplitude scattered through the record. Type 8 (2).

Record 16. Punched animal's right eye with pencil. Animal blinked. Electrode: Left mid. forebrain. The record shows several short series which reach 10 mm. in amplitude. Type 8 (2).

Record 17. Animal passive in the room light. Electrode: left middle forebrain. The record shows a short series at the first which reaches 9 mm. in amplitude. Type 8 (2).

Record 18. This record did not print well enough to read. It was HCl on right foot. Animal struggled. Electrode: left middle forebrain. Type 10.

Record 19. HCl was placed on the animal's right foot. Animal struggled vigorously. Electrode: right posterior forebrain. The first half of the record is quiet. At the beginning of the second half there commenced an extended regular series which reached a 50 mm. amplitude and remained there to the end of tho record. Type 10 (4).

Record 20. Omitted. Spoiled by termination of film.

Record 21. Closed circuit. The record is negative. Type 1 (0).

Record 22. Pulled and pinched animal's right leg. Animal struggled vigorously and pulled foot up. Electrode: right posterior forebrain. The first of the record is fairly quiet. Then there commences a series which gradually increases in amplitude up to 35 mm. This series lasted for four fifths of the record. Type 11 (4).

Record 23. Animal passive in the dark. Electrode: middle thalamus. The record is negative. Type 1 (0).

Record 24. Animal passive in the dark. Electrode: right middle tectum. The record is negative. Type 1 (0).

Record 25. Punched animal's right eye with pencil. Animal blinked. Electrode: right middle tectum. Just after the start of the record there is a fairly long series which gradually reaches 22 mm. in amplitude. Type 5 (4).

Record 26. Punched animal's leg with pencil. Animal struggled vigorously. Electrode: right middle tectum. The record is

highly active at a uniform level throughout. The throws reach 45 mm. in amplitude. The record is regular. Type 10 (4).

Record 27. Shined match into animal's right eye. Animal passive. Electrode: right middle tectum. At the end of the first third of the record there is a short series which reaches 12 mm. in amplitude. Type 8 (2).

Record 28. Pulled cord attached to right leg. Animal struggled vigorously. Electrode: right middle tectum. The record is highly active throughout. The throws reach 45 mm. in amplitude. The record is regular. Type 11 (4).

Record 29. Pulled animal's right leg. Animal winced and struggled after the record was taken. Electrode: rt. middle tectum. The record shows regular throws of 6 and 7 mm. amplitude. Type 12 (1).

Record 30. Punched animal's right eye with pencil. Animal blinked. Electrode: middle thalamus. The record is quiet for 100 mm. At this point there occurs a very abrupt series which reaches a 40 mm. amplitude. This series is fairly long. Type 5 (4).

Record 31. Frog spontaneously pulled leg up. Electrode: middle thalamus. The first half of the record shows two short series of 30 mm. amplitude superimposed on small activity. Type 4 (4).

Record 32. Punched left leg of animal with pencil. Animal winced. Electrode: middle thalamus. The record shows a long series which is uniformally 15 mm. in amplitude. The last part of the record shows a slightly higher level of activity. Type 10 (4).

Record 33. Placed HCl on right leg of animal. Animal struggled vigorously and tried to remove acid. Electrode: middle thalamus. The first third of the record shows irregular activity which finally reaches 15 mm. in amplitude. Beginning with the second third there is extended activity at the 50 mm. level of amplitude to the end of the record. Type 10 (4).

Record 34. Placed HCl on animal's right leg. Animal struggled vigorously and tried to remove acid. Electrode: rt. middle tectum. The record is highly active throughout at a 40 mm. level of amplitude. The record is regular. Type 10 (4).

Record 35. Punched animal's leg with pencil. Animal struggled vigorously. Electrode: rt. middle tectum. The record is highly active throughout at the level of 45 mm. amplitude. The record is very regular. Type 10 (4).

Frog C March 6, 1933, 9:00 p.m.

Description of records:

Record 1. Closed circuit. The record shows a fairly good base-line with slight 'fuzziness' in one place. Type 1 (0).

Record 2. Animal passive in the room light. Electrode: left anterior forebrain. The record shows small throws of 5 and 6 mm. in the first half. Type 13 (1).

Record 3. Animal passive in the room light. Electrode: rt. post. forebrain. The record shows small throws of 5 and 6 mm. in the last half of the record. Type 13 (1).

Record 4. Open circuit. The record shows uniform 'fuzzy' activity.

Record 5. Punched animal's left eye with pencil. Animal blinked. Electrode: left anterior forebrain. The first 80 mm. of the record are negative. At this point there begins an abrupt series which reaches 30 mm. in amplitude. This series is quite long. In the last fifth of the record there is another series which reaches 15 mm. in amplitude. Type 5 (4).

Record 6. Punched animal's left eye with pencil. Animal blinked. Electrode: rt. posterior forebrain. The first 100 mm. of the record are negative. At the end of this section there is an abrupt series which reaches 25 mm. in amplitude. The last third of the record is negative. Type 5 (4).

Record 7. Punched animal's leg with pencil. Animal winced. Electrode: rt. posterior forebrain. The record starts, quietly, but soon there begins gradually a series which reaches 18 mm. in amplitude, and then tapers off rather abruptly. This series is quite short. The last half of the record is quiet. Type 4 (4).

Record 8. Punched animal's left leg with pencil. Animal winced. Electrode: left anterior forebrain. The first 70 mm. of the record is very slightly active. At this point there begins a series which lasts to the end of the record and reaches 25 mm. in amplitude. This series is irregular. Type 11 (4).

Record 9. Rubbed animal's back with pencil. Animal winced. Electrode: left anterior forebrain. The first 100 mm. of the record is quiet. At this point there occurs a short series which reaches 20 mm. in amplitude. At the beginning of the second half of the record there is a series which lasts to the end of the record, which reaches 20 mm. in amplitude. Type 11 (4).

Record 10. Rubbed animal's back with pencil. Animal winced slightly. Electrode: rt. posterior forebrain. The first 30 mm. of the record are negative. At this point there starts an

extended series which lasts nearly the full length of the record and reaches 25 mm. in amplitude. Type 10 (4).

Record 11. Hit animal's back with pencil several times, lightly. Animal passive. Electrode: rt. posterior forebrain. There are four short series of 10 mm. amplitude scattered throughout the record. Type 8 (2).

Record 12. Punched animal's right eye with pencil. Animal blinked. Electrode: rt. posterior forebrain. 20 mm. after the beginning of the record there is an abrupt series which reaches 40 mm. in amplitude. This series extends at a 20 mm. level for half of the record. Type 11 (4).

Record 13. Punched animal's right eye with pencil. Animal blinked. Electrode: left anterior forebrain. The first 50 mm. of the record are negative. At this point there starts an abrupt series which reaches 33 mm. in amplitude. This series continues to the end of the first half of the record. At the beginning of the last third of the record there is a short series which reaches 15 mm. in amplitude. Type 5 (4).

Record 14. Animal struggled spontaneously. Electrode: left anterior forebrain. The record is active throughout with the throws reaching 20 mm. in amplitude. Type 11 (4).

Records 15 and 16 omitted.

Record 17. Animal passive in the room light. Electrode: middle thalamus. The record is negative. Type 1 (0).

Record 18. Animal passive in the room light. Electrode: left middle tectum. The record is negative. Type 1 (0)..

Record 19. Punched animal's left eye with pencil. Animal blinked Electrode: left mid. tectum. In the middle of the record there is an abrupt short series which reaches 20 mm. Following this there is another series which reaches 15 mm. amplitude. Type 4 (4).

Record 20. Punched animal's left eye with pencil. Animal blinked. Electrode: middle thalamus. The first 40 mm. of the record is only slightly active. At this point there starts abruptly a series which reaches 30 mm. in amplitude and lasts irregularly to the end of the record. At the very end of the record there is a fast series which reaches 20 mm. Type 11 (4).

Record 21. Pulled cord attached to animal's left leg. Animal struggled and tried to flex leg. Electrode: middle thalamus. The record is highly active at the start with a series which reaches 40 mm. in amplitude. This series lasts in regular fashion until the last 100 mm. of the record. Type 10 (4).

Record 22. Pulled cord attached to left leg of animal. Animal flexed leg and wriggled slightly. Electrode: left mid. tectum.

The first 50 mm. of the record are quiet. At this point there begins a series which reaches 30 mm. in amplitude and last practically to the end of the record. The record is irregular. Type 11 (4).

Record 23. Punched animal's leg with pencil. Animal struggled slightly. Electrode: left middle tectum. The record is short but shows a short series which reaches 30 mm. Type 4 (4).

Record 24. Punched animal leg with pencil. Animal struggled slightly. Electrode: middle thalamus. The record starts with a series which reaches 35 mm. in amplitude and is fairly long in duration. Type 5 (4).

Record 25. Pulled cord attached to legs (hind) animal drew legs up and struggled slightly. Electrode: middle thalamus. The record shows an abrupt series just after the record started which reaches 30 mm. in amplitude and then gradually tapers off. Just before the second half of the record there is another series which reaches 20 mm. in amplitude. Type 5 (4).

Record 26. Pulled string attached to legs of animal. Animal flexed legs and struggled. Electrode: left middle tectum. The record is highly active throughout except for the last 80 mm. The amplitude in the first half reached 25 mm. in the second half 35 mm. in amplitude. The record is irregular. Type 11 (4).

Record 27. Animal struggled violently, spontaneously. Electrode: left middle tectum. The record is regularly active throughout. The throws range from 20 to 25 mm. in amplitude. Type 10 (4).

Record 28. Animal struggled violently spontaneously. Electrode: middle thalamus. The record is highly active throughout at a level of from 35 to 40 mm. in amplitude. The record is very regular in height. Type 10 (4).

Record 29. Animal struggled violently spontaneously. Electrode: middle thalamus. The record is highly active at a 35 to 40 mm. level throughout. The record is very regular. Type 10 (4).

Record 30. Punched animal's right eye with pencil. Animal blinked. Electrode: middle thalamus. The first 100 mm. of the record are quiet. At this point there is an abrupt series which reaches 40 mm. in amplitude. This series is quite long, but gradually tapers off before the end of the record. Type 5 (4).

Record 31. Punched animal's right eye with pencil. Animal blinked. Electrode: left middle tectum. The first 80 mm. of the record are quiet. At this point there is an abrupt series which reaches 30 mm. in amplitude and then gradually tapers off. This series is long. Type 5 (4).

Record 32. Tapped animal's back with pencil several times. Animal winced slightly. Electrode: left middle tectum. The record shows several short series which reach 10 mm. in amplitude. Type 8 (2).

Record 33. Hit back with pencil. Animal struggled violently. Electrode: middle thalamus. The record is highly active throughout at the 35 to 40 mm. level. The record is very regular. Type 10 (4).

Frog D March 20, 1933, 8:00 p.m.

Description of Records:

Record 1. Animal passive in the room light. Electrode: right mid. forebrain. The record is negative. Type 1 (0).

Record 2. Animal passive in the room light. Electrode: left post. forebrain. The record is negative. Type 1 (0).

Record 3. Punched animal's left eye with pencil. Animal blinked. Electrode: left posterior forebrain. The first 100 mm. of the record are quiet. At the beginning of the next section there is a very abrupt series which reaches 40 mm. in amplitude. The record is irregularly active at a 20 to 25 mm. level to the end of the record. Type 11 (4).

Record 4. Punched animal's left eye with pencil. Animal blinked. Electrode: rt. middle forebrain. The first third of the record is quiet. At the beginning of the second third there is an abrupt series which reaches 30 mm. in amplitude and then gradually tapers off. This series is quite long. Type 5 (4).

Record 5. Punched animal's left leg with pencil. Animal wriggled. Electrode: ft. middle forebrain. There is a short series which reaches 11 mm. in amplitude toward the end of the record. Type 8 (2).

Record 6. Rubbed animal's back with pencil. Animal winced. Electrode: rt. middle forebrain. The record shows two series one at the first and one toward the last of the record which reach 10 mm. in amplitude and are fairly long. Type 9 (2).

Record 7. Punched animal's right leg with pencil. Animal winced slightly. Electrode: left posterior forebrain. There is a series at the first of the record which reaches 20 mm. and is quite long. The last half of the record shows small activity. Type 5 (4).

Record 8. Punched animal's foot with pencil. Animal winced slightly. Electrode: left posterior forebrain. The record shows a fairly long series which reaches 16 mm. in amplitude and then gradually tapers off. The last half of the record is fairly quiet. Type 5 (4).

Record 9. Sounded quincke tube (softly) into right ear of animal. Animal passive. Electrode: left posterior forebrain. The record shows small throws of 5 and 6 mm. scattered irregularly throughout the record. In the first there are the rhythmic throws noted later with the tuning fork. Type 13 (1).

Record 10. Sounded quincke tube into right ear of animal. This was a louder sound than in 9. Animal passive. Electrode: right mid. forebrain. The record shows irregular activity of 6 and 7 mm. scattered through the record. Type 13 (1).

Record 11. Sounded quincke tube into right ear of animal. Loud. Animal passive. Electrode: right mid. forebrain. The record shows 6 and 7 mm. throws irregularly scattered through the first half of the record. Type 13 (1).

Record 12. Pulled left leg of animal with cord. Animal flexed leg. Electrode: right mid. forebrain. The record shows a long series of 10 to 12 mm. amplitude. Type 9 (2).

Record 13. Pulled left leg of animal with cord. Animal flexed leg. Electrode: left posterior forebrain. The record shows a series which reaches 12 mm. in amplitude in the first of the record. In the center of the record there is another series which reaches 12 mm. in amplitude. Type 9 (2).

Record 14. Punched animal's right leg with pencil. Animal struggled. Electrode: left posterior forebrain. The first 100 mm. of the record is fairly quiet. At this point there gradually starts a series which reaches an amplitude of 20 mm. and continues active at a uniform level to the end of the record. Type 10 (4).

Record 15. Punched animal's right leg with pencil. Animal struggled. Electrode: rt. middle forebrain. The record is uniformally active throughout at the 20 mm. level of amplitude. Type 10 (4).

Record 16. Animal spontaneously struggling. Electrode: rt. middle forebrain. The record starts with activity at the 20 mm. level. In the center of the record there are three series which reach 50 mm. in amplitude and are followed by slow throws which are probably movement of the electrode. The record tapers off at the very end. Type 11 (4).

Record 17. Punched the first phlanges on the left leg. Animal squirmed slightly and extended body. Electrode: left posterior forebrain. There is the end of a series at the first of the record which reaches 15 mm. amplitude. The rest of the record is slightly active. Type 4 (4).

Record 18. Punched animal's right eye with pencil. Animal blinked. Electrode: left posterior forebrain. There is a fairly short series at the first of the record which reaches 15 mm. In the last third of the record there is another short series which reaches 25 mm. in amplitude. Type 5 (4).

Record 19. Punched animal's right eye with pencil. Animal had eye closed, but winced slightly. Electrode: rt. middle forebrain. The first part of the record shows small activity. At the beginning of the second third of the record there is an abrupt series which reaches 30 mm. in amplitude. This is followed by a longer series which reaches 20 mm. in amplitude. Type 5 (4).

Record 20. Punched animal's right eye with pencil. Animal blinked. Electrode: rt. mid. forebrain. The first 100 mm. of the record are quiet. At the beginning of the next section there is an abrupt series which last for one half of the record and reaches 25 mm. in amplitude. Type 11 (4).

Record 21. Punched animal's right leg with pencil. Animal struggled. Electrode: rt. mid. forebrain. The record starts with an extended series which reaches 20 mm. in amplitude. This series gradually tapers off into scattered 10 mm. activity. Type 10 (4).

Record 22. Animal spontaneously struggling from former stimulation. Electrode: rt. mid. forebrain. The record shows an abrupt series at the first which reaches 40 mm. in amplitude. The record then is active at a 15 mm. level until the last fifth of the record. At this point there occurs another abrupt series which reaches 40 mm. amplitude. Type 11 (4).

Record 23. Punched animal's right leg with pencil. Animal struggled vigorously. Electrode: left posterior forebrain. The last half of the record shows a series which reaches 25 mm. amplitude. Type 10 (4).

Frog F March 22, 1933, 4:00 and 8:00 p.m.

Description of Records:

Record 1. Closed circuit. The record is negative with a fairly large base line. Type 1 (0).

Record 2. Animal passive in the room light. Electrode: left, anterior forebrain. The record shows small scattered activity of 5 and 6 mm. amplitude. Type 13 (1).

Record 3. Animal passive in the room light. Electrode: rt. posterior forebrain. The record is negative. Type 1 (0).

Record 4. Sounded quincke tube on right side of animal. Electrode: left anterior forebrain. The animal was passive. The record is negative. Type 1 (0).

Record 5. Sounded quincke tube into right ear of animal. Animal was passive. Electrode: rt. posterior forebrain. The record is negative. Type 1 (0).

Record 6. Sounded Galton whistle into right ear of animal. Animal was passive. Electrode: left anterior forebrain. The record shows long series scattered through the record which reach 10 mm. in amplitude. Type 9 (2).

Record 7. Sounded Galton whistle into right ear of animal. The animal was passive. Electrode: rt. posterior forebrain. The record shows small activity of 5 and 6 mm. scattered irregularly throughout. Type 13 (1).

Record 8. Sounded 325 d.v. tuning fork into right ear of animal. The animal was passive. Electrode: lft. anterior forebrain. The record shows scattered activity throughout the record. There are three short series one of which reaches 50 mm. in amplitude. Type 4 (4).

Record 9. Sounded 325 d.v. tuning fork into right ear of animal. The animal was passive. Electrode: rt. post. forebrain. The first half of the record shows very regular activity which occurs rhythmically as three fast throws and then a slow throw. These throws are of 10 mm. amplitude. The record gets more irregular in the last half where some of the throws reach 12 mm. amplitude. Type 6 (2).

Record 10. Sounded 325 d.v. tuning fork into right ear of animal, and at same time punched animal's back with pencil. Animal struggled. Electrode: left ant. forebrain. The first 60 mm. of the record is fairly quiet. From this point on there commences a series which reaches one peak at 30 mm. another at 25 and a third at 60 mm. amplitude. This is really all one series. There is a slow throw after the 60 mm. series which looks like electrode movement. The last fourth of the record is not as active. Type 11 (4).

Record 11. Punched animal's back with pencil. Animal winced. Electrode: rt. post. forebrain. The record shows three series the largest throws of which reach 30 mm. in amplitude. The other throws are about 15 mm. in amplitude. Type 5 (4). minus.

Record 12. Punched animal's leg with pencil. Animal wriggled and winced. Electrode: rt. post. forebrain. The record commences with an extended series which reaches 20 mm. in amplitude. The series is fairly uniform in amplitude. The last third of the record is negative. Type 10 (4).

Record 13. Punched animal's left eye with pencil. Animal blinked. Electrode: rt. posterior forebrain. The record

shows a short abrupt series just after the record started which reaches 30 mm. in amplitude. At the beginning of the second third of the record there is another longer series which reaches 16 mm. in amplitude. Type 5 (4).

Record 14. Punched animal's left eye with pencil. Animal blinked. Electrode: left anterior forebrain. The record is quiet for 50 mm. At the end of this section there occurs an abrupt short series which reaches 30 mm. in amplitude. It then ends rather abruptly into small activity. The last third of the record is negative. Type 4 (4).

Record 15. Punched animal's left leg with pencil. Animal winced slightly. Electrode: left anterior forebrain. There is a short series in the first of the record which reaches 10 mm. in amplitude. Type 8 (2).

Record 16. Punched animal's back with pencil. Animal winced slightly. Electrode: left anterior forebrain. There are several short series which reach 10 mm. in amplitude. Type 8 (2).

Record 17. Pulled string attached to right leg of animal. Animal flexed leg and struggled. Electrode: left anterior forebrain. The record is active throughout. In the first two thirds of the record the largest throws are 20 mm. in amplitude. In the last third there is a short series which reaches 50 mm. in amplitude. Type 11 (4).

Record 18. Pulled string attached to right leg of animal. The animal flexed this leg and struggled. Electrode: rt. posterior forebrain. The record is active throughout at a 20 mm. level. There is one throw which reaches 40 mm. in amplitude. Type 10 (4).

Record 19. Blew at animal. Animal passive. Electrode: rt. posterior forebrain. The record is negative. Type 1 (0).

Record 20. Pulled string attached to animal's right leg. Animal tried to flex leg and struggled. Electrode: rt. posterior forebrain. The record is active throughout reaching 25 mm. in amplitude. The last third of the record is slightly more active than the rest of the record. Type 10 (4).

Frog G Check: Animal Dead.
April 6, 1933, 8:00 p.m.

Description of Records:

Record 1. Electrode left mid. forebrain. The record is negative. Type 1 (0).

Record 2. Electrode 1, open circuit. The record is regularly 'fuzzy' throughout.

Record 3. Closed circuit. The record is negative, but with a large baseline. Type 1 (0).

Record 4. 325 tuning fork on open circuit. The record is exactly like record 2.

Record 5. Sounded 325 d.v. tuning fork. Electrode left mid. forebrain. The record is negative, like no. 1. Type 1 (0).

Record 6. Closed circuit with 325 d.v. tuning fork. The record is negative like no. 3. Type 1 (0).

Record 7. Open circuit and 325 d.v. tuning fork. Electrode off tissue. The record is negative. Type 1 (0).

Record 8. Electrode no. 2 off tissue. Open circuit and 325 d.v. tuning fork. The record is quiet except for one spurious throw. Type 1 (0).

Record 9. Electrode left mid. forebrain. Sounded 325 d.v. tuning fork. The record shows a few scattered throws at the first of the record. Type 1 (0).

Record 10. Electrode left mid. forebrain. The record is negative. Type 1 (0).

Record 11. Open circuit and 325 d.v. tuning fork. The record is negative. Type 1 (0).

Record 12. Open circuit. The record is negative. Type 1 (0).

Frog I April 7, 1933, 9:30 p.m.

Description of Records:

Record 1. Animal passive in the dark. Electrode: anterior rt. and lft. forebrain. The record shows scattered throws of 6 and 7 mm. amplitude. Type 13 (1).

Record 2. Animal passive in the dark. Electrode: posterior rt. and lft. forebrain. The record shows scattered throws of a 6 and 7 mm. level throughout. Type 13 (1).

Record 3. Open circuit. Negative.

Record 4. Closed circuit. The record shows a fairly steady base line with a few irregularities.

Record 5. Punched animal's left eye with pencil. Animal blinked. Electrode: anterior rt. and lft. forebrain. The record shows an abrupt series which reaches 30 mm. in amplitude just after the start of the record. The last three fourths of the record are quiet. Type 5 (4).

Record 6. Punched animal's left eye with pencil. Animal blinked. Electrode: post. rt. ant. lft. forebrain. The record shows a short series which reaches 10 mm. in amplitude at the first of the record. The record is very short. Type 8 (2).

Record 7. Animal passive in the dark. Electrode: post. rt. and lft. forebrain. The record shows small scattered throws of 6 and 7 mm. Type 13 (1).

Record 8. Animal passive in the dark. Electrode: anterior rt. and lft. forebrain. The record shows scattered throws of 6 and 7 mm. amplitude. Type 13 (1).

Record 9. Closed circuit. The record is quiet. Type 1 (0).

Record 10. Shined light into right eye of animal. Animal passive. Electrode: anterior rt. and lft. forebrain. The record shows two series which are fairly long which reach 10 mm. in amplitude as well as numerous small series of 8 mm. amplitude. Type 8 (2).

Record 11. Shined flashlight into right eye of animal. Animal passive. Electrode: posterior rt. and lft. forebrain. The record is short. The record shows two series which reach 10 mm. in amplitude which are fairly long. Type 8 (2).

Record 12. Sounded 325 d.v. tuning fork into right ear of animal. Animal passive. Electrode: anterior rt. and lft. forebrain. The record shows a few scattered throws in the last half of the record of 6 mm. amplitude. Type 13 (1).

Record 13. Sounded 325 d.v. tuning fork into right ear of animal. Animal winced. Electrode: posterior rt. and lft. forebrain. The first two thirds of the record is quiet. In the last third there is a series which reaches 20 mm. in amplitude. This series is fairly long. Type 5 (4).

Record 14. Sounded 387 d.v. fork into right ear of animal. Animal passive. Electrode: anterior rt. and lft. forebrain. The record shows scattered throws of 6 and 7 mm. amplitude throughout. Type 13 (1).

Record 15. Sounded 387 d.v. fork into right ear of animal. Animal passive. Electrode: post. rt. and lft. forebrain. The record shows throws of 7 and 8 mm. scattered in short series throughout the record. Type 8 (2) minus.

Record 16. Sounded 488 d.v. fork into right ear of animal. Animal passive. Electrode: post. rt. and lft. forebrain. The record shows throws of 8 mm. in short series throughout the record. Type 8 (2) minus.

Record 17. Sounded 488 d.v. tuning fork into right ear of animal. Animal passive. Electrode: anterior rt. and lft. forebrain. The record shows short series of 8 and 9 mm. am-

plitude throughout the record fairly evenly spaced. Type 8 (2).

Record 18. Sounded harmonium (low pitch) into right ear of animal. Animal passive. Electrode: anterior rt. and lft. forebrain. The record shows evenly spaced short series of 8 mm. amplitude through the record. Type 8 (2) minus.

Record 19. Sounded harmonium (high) into right ear of animal. Animal passive. Electrode: posterior rt. and lft. forebrain. The record shows several series which reach 9 and 10 mm. in amplitude. These series are much longer than in 18. Type 9 (2).

Record 20. Shined flashlight into right eye of animal. Animal passive. Electrode: post. rt. and lft. forebrain. There are several short series scattered through the record which reach 10 mm. in amplitude. Type 8 (2).

Record 21. Punched animal's right eye with pencil. Animal blinked. Electrode: anterior rt. and lft. forebrain. The record starts with a fairly long and abrupt series which reaches 20 mm. in amplitude. This gradually tapers off and is followed by another abrupt series which reaches 20 mm. and then tapers off. The last half is quiet. Type 5 (4).

Record 22. Punched right eye of animal with pencil. Animal blinked. Electrode: posterior rt. and lft. forebrain. There is an abrupt series in the first fourth of the record which reaches 18 mm. in amplitude. This series is fairly short. There are several short series in the rest of the record which reach 8 mm. in amplitude. Type 4 (4).

Record 23. Punched animal's leg with pencil. Animal wriggled and tried to flex leg. Electrode: post. rt. and lft. forebrain. The record shows activity all the way through which reaches 17 mm. in amplitude, but is very irregular. There are three peaks. Type 11 (4).

Record 24. Punched animal's back with pencil. Animal winced. Electrode: post. rt. and lft. forebrain. The record shows five series which merge gradually into one another and reach 16 mm. in amplitude. Type 5 (4).

Record 25. Hit leg with pencil. Animal struggled and tried to flex leg. Electrode: anterior rt. and lft. forebrain. The record is fairly uniformally active throughout, showing an amplitude of 20 mm. Type 10 (4).

Record 26. Animal struggling spontaneously. Electrode: anterior rt. and lft. forebrain. The record is irregularly active throughout, the throws reaching an amplitude of 25 mm. There are two increases in amplitude in the record. Type 11 (4).

Record 27. Hit back with pencil. Animal stiffened and tried to flex legs. Electrode: anterior rt. and lft. forebrain. The record is irregularly active throughout. The throws show a maximum amplitude of 30 mm. The first half of the record is more active than the last. Type 11 (4).

Record 28. Hit animal's back with pencil. Animal struggled vigorously. Electrode: post. rt. and lft. forebrain. The record is irregularly active throughout and the maximum amplitude reaching 25 mm. The last 30 mm. of the record are quiet. Type 11 (4).

Record 29. Animal struggling spontaneously and flexing legs. Electrode: post. rt. and lft. forebrain. The record is irregularly active throughout the throws reaching an amplitude of 20 mm. Type 11 (4).

Record 30. Pulled out legs. Animal flexing legs vigorously. Electrode: anterior rt. and lft. forebrain. The first 100 mm. of the record are quiet. Then there starts gradually a series which reaches 50 mm. in amplitude and remains highly and irregularly active to the end of the record. Type 11 (4).

Record 31. Animal struggling spontaneously. Electrode: anterior rt. and lft. forebrain. The record shows short series of throws which reach an amplitude of 40 mm. There are eight of these in the record. There is also a longer series at the first of the record which reaches 20 mm. Type 4 (4).

Record 32. Pulled cord attached to legs. Animal struggled and tried to flex legs. Electrode: post. rt. and lft. forebrain. The record is highly active showing base of 20 mm. amplitude on which are superimposed short abrupt series which reach 60 mm. in amplitude. The first half of the record is more active than the last half. Type 11 (4).

Record 33. Animal struggled spontaneously. Electrode: anterior rt. and lft. forebrain. The record is highly active except for a short part in the last fourth of the record. The throws reach 20 to 22 mm. in amplitude. The record is irregular. Type 11 (4).

Record 34. Pulled cord attached to legs. Animal flexed legs. Electrode anterior rt. and lft. forebrain. The record starts fairly quietly but at the end of the first third shows a series which reaches 20 mm. In the middle of the record there is a long series which reached 30 mm. in amplitude. This series tapers off before the end of the record. Type 5 (4).

Record 35. Pulled cord attached to legs. Animal flexed legs. Electrode: post. rt. and lft. forebrain. There is a fairly long series at the first of the record which reaches 30 mm. in amplitude. This series tapers off into irregular activity of 10 mm. level. At the end of the record there is another series which reaches 30 mm. amplitude. Type 5 (4).

Record 36. Sounded 325 tuning fork into right ear of animal. Animal passive. Electrode: anterior rt. and lft. forebrain. The record shows several short series which reach 10 mm. in amplitude. Type 8 (2).

Record 37. Sounded 325 d.v. tuning fork into right ear of animal. Animal passive. Electrode: post. rt. and lft. forebrain. The record shows several short series which reach 10 to 12 mm. in amplitude, scattered through the record at equally spaced intervals. Type 8 (2).

Record 38. Punched animal's left eye with pencil. Animal blinked. Electrode: anterior rt. and lft. forebrain. The record shows a fairly abrupt series just after the record started which reaches 35 mm. in amplitude and then gradually tapers off to the center of the record. The last half of the record is quiet. Type 5 (4).

Record 39. Punched animal's right eye with pencil. Animal blinked. Electrode: post. rt. and lft. forebrain. The record shows a long series which reaches 18 mm. in amplitude and lasts for three fourths of the record. The series is uniform in amplitude. Type 10 (4).

Frog J April 14, 1933, 9:00 p.m.

Description of Records:

Record 1. Closed circuit. The record is negative, but 'fuzzy'. Type 1 (0).

Record 2. Animal passive in the dark. Electrode: rt. mid. tectum. The record is negative. Type 1 (0).

Record 3. Animal passive in the dark. Electrode: lft. mid. tectum. The record shows scattered throws of 5 and 6 mm. throughout. Type 12 (1).

Record 4. Shined flashlight into right eye of animal. Animal passive. Electrode: rt. mid. tectum. The record is negative. Type 1 (0).

Record 5. Shined flashlight into right eye of animal. Animal passive. Electrode: lft. mid. tectum. The record is negative. Type 1 (0).

Record 6. Shined light into right eye three times. Animal passive. Electrode: lft. mid. tectum. The record shows small throws of 5 and 6 mm. amplitude throughout. Type 12 (1).

Record 7. Shined light into right eye three times. Animal passive. Electrode: rt. mid. tectum. The record shows uniform scattered throws throughout. Type 12 (1).

Record 8. Open circuit. Negative.

Record 9. Punched animal's back with pencil. Animal winced. Electrode: rt. mid. tectum. The record is active throughout with four peaks in amplitude of 18 mm. The record is irregular. Type 11 (4).

Record 10. Punched animal's back with pencil. Animal winced, and struggled. Electrode: lft. med. tectum. The record commenced with an extended series which reaches 35 mm. in amplitude and then ends rather abruptly in small activity. At the beginning of the second third of the record there is a very large series which gradually increases in amplitude until it reaches 55 mm. in height, which lasts at this amplitude to the end of the record. Type 11 (4).

Record 11. Animal passive. Electrode: lft. mid. tectum. Record taken too soon so that record is negative. Type 1 (0).

Record 12. Punched animal's left eye with pencil. Animal blinked. Electrode: rt. mid. tectum. The record shows a short series of 15 mm. amplitude at the end of the first half of the record. There is another series which reaches 25 mm. amplitude in the last third which ends abruptly. Type 5 (4).

Record 13. Animal passive in the dark. Electrode: lft. thalamus. The record is negative. Type 1 (0).

Record 14. Animal passive in the dark. Electrode: rt. cerebellum. The record is negative. Type 1 (0).

Record 15. Shined flashlight into right eye of animal. Animal passive. Electrode: rt. cerebellum. The record shows scattered throws of irregular nature in the last half of the record. Type 13 (1).

Record 16. Shined flashlight into right eye of animal. Animal passive. Electrode: lft. thalamus. The record shows scattered throws of 6 and 7 mm. throughout. Type 12 (1).

Record 17. Shined flashlight into right eye of animal three times. Animal passive. Electrode: lft. thalamus. The record shows scattered throws of 7 and 8 mm. throughout. Type 12 (1).

Record 18. Shined flashlight into right eye of animal three times. Animal passive. Electrode: rt. cerebellum. There are three short series which reach 10 mm. amplitude, one at the first of the record and two in the last half of the record. Type 8 (2).

Record 19. Punched animal's left eye with pencil. Animal blinked. Electrode: rt. cerebellum. The first third of the record is fairly quiet. At the beginning of the second

third there is a short series which reaches 15 mm. in amplitude. In the middle of the last third there is a longer series which reaches 25 mm. in amplitude. Type 5 (4).

Record 20. Punched animal's left eye with pencil. Animal blinked. Electrode: left thalamus. There is a fairly short series at the end of the first third of the record which reaches 20 mm. amplitude. There are two other series which are longer but not as great in amplitude, one in the middle of the second third and one in the last third of the record which reach 14 mm. in amplitude. Type 5 (4).

Record 21. Punched back with pencil. Animal winced. Electrode: lft. thalamus. The record shows three series which reach 18 mm. in amplitude. The series are fairly long. Type 5 (4).

Record 22. Punched animal's back with pencil. Animal winced. Electrode: rt. cerebellum. The record shows three series which merge into one another. These series reach 20 mm. in amplitude. The record is fairly active throughout. Type 11 (4).

Record 23. Animal passive in the dark. Electrode: rt. mid. tectum. The record is negative. Type 1 (0).

Record 24. Animal passive in the dark. Electrode: lft. lateral tectum. The record is negative. Type 1 (0).

Record 25. Shined light into animal's right eye. Animal passive. Electrode: lft.lateral tectum. There are very short series scattered through the record which reach 10 mm. Type 8 (2).

Record 26. Shined light into animal's right eye three times. Animal passive. Electrode: rt. mid. tectum. The animal had its eye wide open. There are several short series in the record which reach 10 mm. Type 8 (2).

Record 27. Shined light into animal's right eye. Electrode: rt. mid. tectum. The animal was passive. There is scattered activity throughout, with one series which reaches 10 mm. in the center of the record. Type 8 (2).

Record 28. Shined flashlight three times into animal's right eye. Animal's eye wide open, but passive. Electrode: rt. mid. tectum. The record shows a short series which reaches 20 mm. in the first of the record. The first third shows three scattered throws. Type 4 (4).

Record 29. Punched animal's right eye with pencil. Animal

blinked. Electrode: rt. mid. tectum. The first three fourths of the record shows small scattered activity. In the last fourth there is a series which reaches 14 mm. in amplitude and is fairly long. Type 9 (2).

Record 30. Punched left eye with pencil. Animal blinked. Electrode: lft. lateral tectum. The first two thirds of the record are quiet except for small scattered activity. In the last third there is a gradual series which reaches 20 mm. in amplitude. Type 5 (4).

Record 31. Punched animal's body with pencil. Animal winced slightly. Electrode: lft. lateral tectum. The record shows two series which reach 20 mm. fairly abruptly and three smaller series which reach 12 mm. amplitude. Type 4 (4).

Record 32. Punched animal's body with pencil. Animal winced. Electrode: rt. mid. tectum. The record shows three series, one in each third of the record, which reach 18 mm. in amplitude. The series are fairly long and gradual. Type 5 (4).

Record 33. Punched animal's back with pencil. Animal winced very slightly. Electrode: lft. lateral tectum. The record shows four fairly long series which reach 11 mm. in amplitude. Type 9 (2).

Record 34. Animal passive in the dark. Electrode: lft. post. forebrain. The record is negative. Type 1 (0).

Record 35. Animal passive in the dark. Electrode: rt. mid. forebrain. The record shows scattered throws and two series which reach 10 mm. in amplitude. Type 8 (2).

Record 36. Shined flashlight into right eye of animal. Animal passive. Electrode: rt. mid. forebrain. The record shows several short series which reach 10 mm. in amplitude. There is also small activity scattered throughout the record. Type 8 (2).

Record 37. Shined flashlight into right eye of animal. Animal passive. Electrode: lft. post. forebrain. The record shows several short series which reach 10 mm. in amplitude, along with scattered small activity. Type 8 (2).

Record 38. Punched animal's back with pencil. Animal winced. Electrode: lft. post. forebrain. The record is active throughout. It shows four increases in amplitude which measure 15 mm., 25 mm., 30 mm. and 30 mm. respectively. Type 11 (4).

Record 39. Punched animal's back with pencil. Animal winced. Electrode: rt. mid. forebrain. The record is highly active throughout with three peaks in amplitude which measure 25 mm., 20 mm. and 15 mm. respectively. Type 11 (4).

Record 40. Closed. This is a test with a new tube and no animal. The record is negative, but 'fuzzy'. Type 1 (0).

Record 41. Open circuit. This is also a test. The record is negative. Type 1 (0).

Frog K April 15, 1933, 8:00 p.m.

Description of Records:

Record 1. Closed circuit. There is activity of monophasic type which reaches 10 mm. amplitude. Type 13 (1).

Record 2. Animal passive. Electrode: rt. ant. forebrain. The first two thirds of the record shows small activity. In the last third there is a short series which reaches 15 mm. in amplitude. Type 8 (2).

Record 3. Animal passive. Electrode: lft. mid. tectum. The first half of the record shows small activity. At the beginning of the second half of the record there is a series which reaches 25 mm. amplitude and then tapers off to the end of the record. Type 5 (4).

Record 4. Animal passive in the dark. Electrode: lft. mid. tectum. The record is negative. Type 1 (0).

Record 5. Animal passive in the dark. Electrode: rt. ant. forebrain. The record is negative. Type 1 (0).

Record 6. Lost. End of film.

Record 7. Animal passive in the dark. Electrode: rt. ant. forebrain. The record shows scattered throws of 5 mm. amplitude. Type 13 (1).

Record 8. Shined flashlight into right eye of animal. Animal passive. Electrode: rt. ant. forebrain. The record shows scattered throws of 5 mm. amplitude scattered throughout. Type 13 (1).

Record 9. Shined flashlight into right eye of animal. Animal passive. Electrode: lft. mid. tectum. The record shows scattered throws of 6 mm. amplitude throughout. Type 13 (1).

Record 10. Punched animal's body with pencil and shined light at same time. Animal winced. Electrode: lft. mid. tectum. The record is irregularly active throughout, reaching in the highest throws 20 mm. amplitude. Type 10 (4).

Record 11. Punched animal's body with pencil and shined light in eye at same time. Animal winced. Electrode: rt. ant.

forebrain. The first 60 mm. of the record are quiet. Then there starts fairly abruptly a very long series which last to the end of the series and reaches 25 mm. in amplitude at several points. The throws are fast and irregular. Type 11 (4).

Record 12. Punched animal's right eye with pencil. Animal blinked. Electrode: rt. ant. forebrain. The first third of the record is fairly quiet. At the beginning of the second third there is an abrupt series which reaches 30 mm. amplitude and then tapers down into a long series of 12 mm. throws. At the beginning of the last third of the record there is another series which reaches 15 mm. amplitude. Type 5 (4).

Record 13. Punched animal's left eye with pencil. Animal blinked. Electrode: lft. mid. tectum. The first 70 mm. of the record are quiet. At the end of this section there occurs an abrupt series which reaches 25 mm. and then gradually tapers off. This series is quite long. At the beginning of the last third of the record there is another series which reaches 18 mm. in amplitude. Type 5 (4).

Record 14. Animal passive in room light. Electrode: lft. mid. forebrain. The record is negative. Type 1 (0).

Record 15. Animal passive in room light. Electrode: rt. mid. tectum. The record shows scattered throws of 10 mm. amplitude through the record. Type 13 (1).

Record 16. Animal passive in the dark. Electrode: rt. mid. tectum. The record shows several short series which reach 10 mm. amplitude scattered through the record. Type 8 (2).

Record 17. Animal passive in the dark. Electrode: lft. mid. forebrain. The record shows scattered throws of 8 mm. amplitude throughout the record. Type 13 (1).

Record 18. Shined flashlight into right eye of animal. Animal passive. Electrode: lft. mid. forebrain. The record is negative. Type 1 (0).

Record 19. Shined flashlight into right eye of animal. Animal passive. Electrode: rt. mid. tectum. The record shows several short series of 8 and 13 mm. amplitude throughout the record. Type 8 (2).

Record 20. Shined flashlight three times into right eye of animal. Animal passive. Electrode: rt. mid. tectum. The record is negative. Type 1 (0).

Record 21. Shined flashlight twice into right eye of animal. Animal passive. Electrode: lft. mid. forebrain. The record shows two short series in the first half which reach 12 mm. amplitude. There is other small activity scattered through the record. Type 8 (2).

Record 22. Punched animal's body with pencil. Animal jumped and struggled. Electrode: lft. mid. forebrain. The record is highly active throughout, but very irregular. The highest throws are 30 mm. in amplitude where most of the throws reach 20 mm. Type 11 (4).

Record 23. Punched animal body with pencil. Animal jumped and struggled. Electrode: rt. mid. tectum. The first 40 mm. of the record is quiet. At this point there starts a highly active series which extends to the end of the record. The throws are irregular and reach 30 mm. in amplitude, and all of them are 20 mm. in amplitude. Type 11 (4).

Record 24. Animal passive in the room light. Electrode: lft. post. forebrain. The record is negative. Type 1 (0).

Record 25. Animal passive in the room light. Electrode: rt. lateral tectum. The record shows scattered throws of 6 mm. particularly toward the end of the record. Type 13 (1).

Record 26. Animal passive in the dark. Electrode: rt. lateral tectum. The record shows scattered throws of 6 and 7 mm. amplitude through the record. Type 13 (1).

Record 27. Animal passive in the dark. Electrode: lft. post. forebrain. The record shows scattered throws of 5 and 6 mm. through the record. Type 12 (1).

Record 28. Shined flashlight into right eye of animal. Animal passive. Electrode: lft. post. forebrain. The first two thirds of the record is fairly quiet with a few scattered small throws. The last third shows a series which reaches 12 mm. amplitude. Type 8 (2).

Record 29. Shined flashlight into right eye of animal. Animal passive. Electrode: rt. lateral tectum. The first two thirds of the record shows scattered throws of 5 and 6 mm. amplitude. In the last third there are two short series which reach 10 mm. amplitude. Type 8 (2) minus.

Record 30. Shined flashlight three times into right eye of animal. Animal passive. Electrode: rt. lateral tectum. The record shows a large number of short series, which reach 10 mm. and 12 mm. amplitudes. Some of these are single throws. Type 8 (2).

Record 31. Shined flashlight into right eye of animal three times. Animal passive. Electrode: lft. posterior forebrain. The record shows three fairly long series which are interspersed with smaller activity. These series reach 12 mm. amplitude. Type 9 (2).

Record 32. Punching animal's body with pencil and shinning light. Animal winced and wriggled slightly. Electrode: lft.

post. forebrain. The record is active throughout at a high level. The throws reaching 20 mm. in amplitude. The throws are fast and irregular. Type 11 (4).

Record 33. Punched animal's body with pencil and flashed light. Animal winced and wriggled. Electrode: rt. lateral tectum. The record is uniformally active throughout with the throws reaching 25 mm. amplitude. The last third of the record shows the highest activity. Type 11 (4).

Record 34. Punched animal's left eye twice with pencil. Animal blinked. Electrode: rt. lateral tectum. The first 100 mm. of the record are quiet. At this point there starts abruptly a series which reaches 30 mm. amplitude and decreases to a 15 to 20 mm. level. At the beginning of the last third of the record there is another increase in amplitude to 25 mm. Activity continues to the end of the record. Type 11 (4).

Record 35. Punched animal's left eye with pencil twice. Animal blinked. Electrode: lft. post. forebrain. The first 80 mm. of the record are quiet. At this point there is an abrupt series which reaches first 30 mm. in amplitude then decreases to a 15 to 20 mm. level for a long series. An increase in amplitude occurs at the last third of the record to 25 mm. amplitude and then after a fairly long series a return to the 15 mm. level. Type 11 (4).

Record 36. Animal passive in the room light. Electrode: mid. thalamus. The record is quiet until the last fifth when a fairly long series occurs which reaches 13 mm. in amplitude. Type 9 (2).

Record 37. Animal passive in the room light. Electrode: rt. cerebellum. The record is negative. Type 1 (0).

Record 38. Animal passive in the dark. Electrode: rt. cerebellum. The record shows scattered throws of 5 and 6 mm. throughout. Type 12 (1).

Record 39. Animal passive in the dark. Electrode: mid. thalamus. The record shows irregular throws of 5 to 7 mm. amplitude. Type 13 (1).

Record 40. Shined flashlight into right eye of animal. Animal passive. Electrode: mid. thalamus. The record shows small activity of 5 and 6 mm. interspersed with several 10 mm. throws. Type 8 (2) minus.

Record 41. Shined flashlight into right eye of animal, but eye was partly closed. Animal passive. Electrode: rt. cerebellum. The record shows activity scattered throughout of 5 and 6 mm. amplitude. With a concentration toward the first of the record. Type 12 (1).

Record 42. Punched animal's body with pencil and flashed light at same time. Animal winced and wriggled. Electrode: rt.

cerebellum. The record commences with a series which lasts for the entire record at 16 mm. amplitude. There are five larger and shorter series superimposed on this level which reach 50 mm. in amplitude, but end with a slow impulse and may be movement of the electrode. Type 11 (4).

Record 43. Punched animal's body and flashed light at the same time. Animal winced and struggled. Electrode: mid. thalamus. The record is irregularly active throughout, reaching 25 mm. in amplitude and most of the throws being above 15 mm. amplitude. The last third of the most of the throws being above 15 mm. amplitude. The last third of the record is the most active. Type 11 (4).

Record 44. Shined flashlight into right eye three times. Animal passive with eyes open. Electrode: mid. thalamus. The record shows scattered throws of 5 and 6 mm. throughout. Type 12 (1).

Record 45. Shined flashlight into right eye three times. Animal passive with eyes open. Electrode: rt. cerebellum. The record shows several short series which reach 14 mm. amplitude. These are interspersed with smaller activity. Type 8 (2).

Record 46. Punched animal's left eye with pencil. Animal blinked. Electrode: rt. cerebellum. The beginning of the record shows small activity for 80 mm. Then there appears an abrupt series which reaches 20 mm. amplitude and then gradually tapers off. In the middle of the record there is another shorter series which reaches 14 mm. amplitude. Type 5 (4).

Record 47. Punched animal's right eye with pencil. Animal blinked. Electrode: rt. cerebellum. There is small activity for the first 100 mm. of the record. At the end of this section there is an abrupt series which reaches 32 mm. in amplitude and then gradually tapers off. The last half of the record shows only small activity. Type 5 (4).

Frog M. April 22, 1933, 8:00 p.m.

Description of Records:

Record 1. Animal passive in room light. Electrode: lft. ant. forebrain. The record is negative. Type 1 (0).

Record 2. Animal passive. Electrode: lft. ant. forebrain. The record is negative. Type 1 (0).

Record 3. Animal passive. Electrode: lft. cerebellum. The record is negative. Type 1 (0).

Record 4. Closed circuit. The record is negative. Type 1 (0).

Record 5. Punched right eye of animal with pencil. Closed eye and winced slightly. Electrode: left ant. forebrain. The first 100 mm. of the record are negative. At the end of this section there occurs a very abrupt series which reaches 55 mm. at the outset. The series then tapers off into activity of 30 mm. amplitude. This gradually tapers off into 10 mm. amplitude. The last half of the record is quiet. Type 11 (4).

Record 6. Punched animal's right eye with pencil. Animal blinked and jumped slightly. Electrode: left cerebellum. The first 75 mm. of the record shows small scattered throws. At the end of the second section there is a fairly abrupt series which reaches 23 mm. amplitude. The series gradually subsides into small scattered throws about the middle of the record. The last half of the record is quiet. Type 11 (4).

Record 7. Animal passive in the dark. Electrode: left ant. forebrain. The record is negative. Type 1 (0).

Record 8. Animal passive in the dark. Electrode: left cerebellum. The record is negative except for one single throw of 10 mm. amplitude. Type 1 (0).

Record 9. Shined flashlight into right eye of animal. Animal passive. Electrode: left cerebellum. The record shows a short series of 8 mm. throws at the first of the record the rest of the record is quiet. Type 8 (2) minus.

Record 10. Shined flashlight into right eye of animal. Animal passive. Electrode: lft. ant. forebrain. The record shows scattered throws of 5 mm. throughout and 6 mm. at the end of the record. Type 13 (1).

Record 11. Punched back with pencil. Animal winced and struggled. Electrode: lft. ant. forebrain. Just after the beginning of the record there is an abrupt series which reaches 50 mm. amplitude. This gradually subsides to a level of 30 mm. and then tapers off gradually to a 20 and 10 mm. amplitude. 10 mm. amplitude activity continues to the end of the record. The throws are all fast, but after the middle of the record are somewhat monophasic. Type 11 (4).

Record 12. Punched animal's back with pencil three times. Animal winced and struggled each time. Electrode: left cerebellum. The first 20 mm. of the record are quiet, but then there occurs a short series which reaches 20 mm. amplitude. This subsides and is followed immediately by an extended series which reaches a maximum of 25 mm. and then gradually subsides to 10 mm. amplitude. This is followed by a fairly abrupt and fast series of 25 mm. amplitude which subsides gradually to 15 mm. and then increases gradually to 20 mm. amplitude. 15 mm. amplitude throws continue irregularly to the end of the record and are mainly monophasic. Type 11 (4).

Record 13. Animal passive in the dark. Electrode: lft. mid. forebrain. The record is negative. Type 1 (0).

Record 14. Animal passive in the dark. Electrode: lft. mid. tectum. The record shows a short series of 9 mm. amplitude in the center of the record. Otherwise the record is quiet. Type 8 (2) minus.

Record 15. Shined light into animal's right eye. Animal passive. Electrode: lft. mid. tectum. The record is negative. Type 1 (0).

Record 16. Shined flashlight into right eye of animal. Animal passive. Electrode: lft. mid. forebrain. The record is negative. Type 1 (0).

Record 17. Punched animal's right eye with pencil. Animal blinked. Electrode: lft. mid. forebrain. The first 150 mm. of the record is quiet except for a few scattered throws of 6 mm. amplitude. At the beginning of the next section there commences very abruptly a series which starts at 40 mm. amplitude. This tapers off into 20 mm. throws and then into 10 mm. throws. The last third of the record shows a few scattered throws of 8 mm. Type 11 (4).

Record 18. Punched right eye of animal with pencil. Animal blinked. Electrode: lft. mid. tectum. The first third of the record shows no activity. At the beginning of the next section there is a very abrupt series of 40 mm. amplitude which returns very abruptly to 10 mm. amplitude throws which are scattered to the end of the record. Type 11 (4).

Record 19. Open circuit. Throws of 40 mm. amplitude uniformally. Type 10 (4).

Record 20. Punched animal's back with pencil. Animal struggled, vigorously. Electrode: lft. mid. forebrain. The record shows an abrupt series just after the record started which reaches 30 mm. in amplitude. The record is uniformally active at from 30 to 20 mm. amplitude, fast throws up to 100 mm. of the end of the record. Then the activity subsides and scatters to the 10 mm. level until the end of the record is fairly quiet. Type 10 (4).

Record 21. Punched animal's back three times with pencil. Animal winced and struggled each time. Electrode: lft. med. tectum. The first 75 mm. of the record are quiet. At this point there starts fairly abruptly a series which reaches 25 mm. in amplitude. This series subsides somewhat into a second series at the center of the record of 20 mm. The amplitude again increases to 18 mm. to form a series. These series are not separated by inactivity, but gradually merge into one another. The last series continues with scattered 10 mm. activity at the end of the record. Type 11 (4).

Record 22. Shined flashlight into animal's eyes two times. Animal passive. Electrode: lft. mid. tectum. The record is negative. Type 1 (0).

Record 23. Shined flashlight into animal's eye three times. Animal passive. Electrode: lft. mid. forebrain. The record is negative. Type 1 (0).

Record 24. Closed circuit. The record is negative. Type 1 (0).

Record 25. Animal passive in the dark. Electrode: lft. post. forebrain. The record is negative. Type 1 (0).

Record 26. Animal passive in the dark. Electrode: rt. mid. tectum. The record is negative. Type 1 (0).

Record 27. Shined flashlight into right eye of animal. Animal passive. Electrode: rt. mid. tectum. The record shows scattered activity of 5 mm. amplitude throughout. Type 13 (1).

Record 28. Shined flashlight into right eye of animal. Animal passive. Electrode: lft. post. forebrain. The record shows throws of 5 mm. amplitude scattered throughout. Type 13 (1).

Record 29. Punched animal's right eye with pencil. Animal blinked. Electrode: lft. posterior forebrain. The first 100 mm. of the record are quiet. At this point there is an abrupt series which reaches 40 mm. in amplitude and then subsides to the 30 mm. level. This decreases to the 10 mm. level. The last third of the record is quiet. Type 11 (4).

Record 30. Punched left eye of animal with pencil. Animal blinked. Electrode: rt. mid. tectum. The first third of the record is quiet. At the beginning of the second third there is an abrupt series which reaches 35 mm. then subsides to 10 and then increases to 20 mm. Then tapers off to 10 mm. throws before returning to the base line. The series is fairly short and irregular. The last third of the record is negative. Type 5 (4).

Record 31. Punched body three times with pencil. Animal winced and struggled each time. Electrode: rt. mid. tectum. The record starts quietly. Then there occurs an abrupt series of 15 mm. which tapers off into short scattered series of 10 and 12 mm. At the beginning of the second third of the record there is another abrupt series where the amplitude increases to 20 mm. This series lasts for 70 mm. After 50 mm. of inactivity there is another series of 16 mm. amplitude, which lasts until the next series which is in the center of the last third of the record and reaches 16 mm. amplitude. This tapers off to the end of the record. Type 11 (4).

Record 32. Punched animal's body three times. Animal winced and struggled each time. Electrode: lft. post. forebrain. The first 90 mm. of the record are quiet. At the end of this section there is an abrupt series of 20 mm. amplitude throws which tapers off gradually. In the center of the record there is another series which also reaches 20 mm. amplitude. This series tapers off to the next which also reaches 20 mm. amplitude at the beginning of the last third of the record. It is followed fairly closely by another series which reaches 18 mm. and tapers off to the end of the record. The throws are all fast. Type 11 (4).

Record 33. Animal passive in the dark. Electrode: rt. thalamus. The record is negative. Type 1 (0).

Record 34. Animal passive in the dark. Electrode: lft. cerebellum. The record is negative. Type 1 (0).

Record 35. Shined flashlight into right eye of animal. Animal passive. Electrode: lft. cerebellum. The record shows a short series of 9 mm. throws at the first of the record and a few scattered 5 mm. throws through the record. Type 8 (2) minus.

Record 36. Shined flashlight into right eye of animal. Animal passive. Electrode; rt. thalamus. The record is negative. Type 1 (0).

Record 37. Punched right eye of animal with pencil. Animal blinked. Electrode: rt. thalamus. The first 100 mm. of the record are negative. At the beginning of the next section there is an abrupt series which reaches 35 mm. in amplitude. The decreases in amplitude to 30 mm. then to 10 mm. and finally to zero. The last half of the record is negative. Type 5 (4).

Record 38. Punched left eye of animal with pencil. Animal blinked. Electrode: left cerebellum. The first 30 mm. of the record are negative. After this section there is an abrupt series which reaches 30 mm. in amplitude. This series gradually subsides into 10 mm. activity and finally to the baseline. About the center of the record there is another abrupt series of 20 mm. which is very short. The last half of the record is quiet. Type 5 (4).

Record 39. Punched back twice with pencil. Animal winced and jumpted each time. Electrode: left cerebellum. The first 100 mm. of the record are negative. This is followed by an abrupt series which reaches 20 mm. amplitude. This series is short and gradually subsides to the baseline for a short time and then gradually increases to 20 mm. amplitude for a very long series which finally subsides. Following this long series

in the last 60 mm. of the record there is another series which reaches 20 mm. amplitude and lasts to the end of the record. Type 11 (4).

Record 40. Punched back of animal four times with pencil. Animal jumped and struggled each time. Electrode: rt. thalamus. Just after the record started there is a series which reaches 15 mm. amplitude, and then subsides gradually to the baseline. At the beginning of the second fourth of the record there is a fairly gradual series which reaches 22 mm. amplitude and then gradually subsides. At the beginning of the third fourth of the record there is another series which reaches 20 mm. amplitude and gradually tapers off. In the last fourth there is a series which reaches 15 mm. amplitude lasting to the end of the record. Type 11 (4).

Record 41. Animal struggled spontaneously. Electrode: rt. thalamus. The record is highly active throughout and is really all one series. It starts at 40 mm. amplitude and gradually reduces to 30 and finally to 20 mm. before the record is over. Type 10 (4).

Record 42. Animal passive in the dark. Electrode: rt. post. forebrain. The record is negative. Type 1 (0).

Record 43. Animal passive in the dark. Electrode: lft. lateral tectum. The record is negative. Type 1 (0).

Frog 0 April 25, 1933, 8 p.m.

Description of Records:

Record 1. Closed circuit. The record is negative. Type 1 (0).

Record 2. Animal passive. Electrode: rt. middle forebrain. The record is negative. Type 1 (0).

Record 3. Animal passive but blinking during recording. Electrode: lft. lateral tectum. The record shows characteristic single and double throws of 8 mm. amplitude rhythmically spaced in the record. There are six or seven of these. Type 6 (2).

Record 4. Punched animal's rt. eye with pencil. Animal blinked. Electrode: lft. lateral tectum. The first 40 mm. of the record are quiet. At this point there occurs abruptly a series of fast throws which reaches a maximum of 35 mm. amplitude, and then ends abruptly. The remainder of the record is negative. Type 2 (4).

Record 5. Punched animal's left eye with pencil. Animal

blinked. Electrode: rt. mid. forebrain. The record shows a short series of 5 mm. throws, followed by a single throw of 8 mm. The remainder of the record is negative. Type 13 (1).

Record 6. Punched animal's body with pencil. Animal winced. Electrode: rt. middle forebrain. The record commences quietly but at the end of the first third shows a series of 10 mm. throws which scatters out into 7 mm. throws. At the beginning of the last half of the record there is an extended series which reaches 14 mm. in amplitude. This is followed by a shorter series of 10 mm. amplitude which continues in irregular fashion to the end of the record. Type 9 (2) plus.

Record 7. Punched animal's body with pencil. Animal winced. Electrode lft. lateral tectum. The first half of the record shows scattered throws of 7 and 8 mm. which form in places into short series. At the beginning of the last third of the record there is a series of scattered throws of 10 mm., the throws occurring as single spaced throws. Type 8 (2).

Record 8. Punched foot three times with pencil. Animal wriggled and struggled. Electrode: lft. lateral tectum. The record starts with an extended series of 20 mm. throws. This series gradually dwindles off into 10 mm. throws. Than a series of 25 mm. throws starts abruptly and gradually tapers off into 8 mm. throws. At the beginning of the last third of the record there is an extended series which reaches 30 mm. amplitude and continues at 14 mm. height to the end of the record. Type 11 (4).

Record 9. Punched animal's foot three times. Animal jumped, struggled and tried to flex foot. Electrode: rt. mid. forebrain. The record commences with a series which reaches 30 mm. at the outset and then gradually declines to activity of 10 mm. At the beginning of the second third of the record there is an abrupt series which reaches 35 mm. amplitude. This series gradually tapers off to a 12 mm. level which it maintained to the next series which starts at the last third of the record and reaches 45 mm. amplitude and then gradually tapers off to 12 mm. activity level to the end of the record. The record is active throughout, but irregular. Type 11 (4).

Record 10. Animal passive. Electrode: rt. ant. forebrain. The record is negative. Type 1 (0).

Record 11. Animal passive. Electrode: rt. lateral tectum. The record is negative. Type 1 (0).

Record 12. Punched right eye of animal. Animal blinked and winced slightly. Electrode: rt. lateral tectum. The first 50 mm. of the record is quiet. At the end of this time there is a very abrupt series which reaches 22 mm. amplitude.

This series is very short and ends abruptly, but is immediately followed by an abrupt series of 20 mm. which tapers off gradually to a 11 mm. level and then gradually back to zero. The last half of the record is negative. Type 11 (4).

Record 13. Punched left eye of animal with pencil. Animal blinked and winced slightly. Electrode: rt. ant. forebrain. The first 40 mm. of the record is negative. At the end of this time there is an abrupt series of 25 mm. amplitude, which ends abruptly. This is followed by a small series of 9 mm. amplitude. The last two thirds of the record is negative. Type 4 (4).

Record 14. Punched animal's leg with pencil. Animal winced and tried to flex leg. Electrode: rt. ant. forebrain. The beginning of the record shows scattered throws of 5, 6 and 7 mm. amplitude. At the beginning of the second fourth of the record there is a series which reaches 18 mm. amplitude fairly abruptly and then tapers off into scattered 8 mm. single throws. At the beginning of the last third of the record there is a series of 12 mm. throws which tapers off into the scattered single 8 mm. throws. Type 4 (4) minus.

Record 15. Punched animal's leg with pencil. Tried to flex leg and winced. Electrode: rt. lateral tectum. The record starts with a short series of 10 mm. throws. At the beginning of the second third of the record there is a series of 15 mm. throws, which commences abruptly and then tapers off into scattered throws of 9 mm. amplitude. At the beginning of the last third of the record there is a series of 10 mm. throws, which scattered into single throws of 9 mm. equally spaced. Just before the end of the record there is a short series of 10 mm. amplitude. Type 5 (4) minus.

Record 16. Punched animal's leg with pencil. Animal tried to flex leg and struggled vigorously. Electrode: rt. lateral tectum. The record shows maximum activity throughout. At the first of the record there is activity of 30 mm. which lasts for the first third of the record. It then gradually decreases to about 20 mm. The average for the entire record is about 20 mm. amplitude. Type 11 (4).

Record 17. Punching foot with pencil. Animal tried to flex foot and struggled vigorously. Electrode: rt. ant. forebrain. The record starts with a series of 18 mm. which tapers off into 10 mm. activity. Beginning with the second third of the record there is activity for 150 mm. of 20 mm. amplitude. The last fifty mm. of the record shows activity of 40 mm. amplitude. The record is active throughout, but varies in amplitude. Type 11 (4).

Record 18. Punching foot with pencil. Animal tried to flex foot and struggled vigorously. Electrode: rt. ant. forebrain. The record shows very high activity throughout, with very fast

throws which vary from 35 to 40 mm. an amplitude throughout the record. Type 10 (4).

Record 19. Animal spontaneously croaking. Electrode: post. rt. forebrain. The record begins with scattered throws of 10 mm. which form a short series just before the middle of the record. The last half of the record is quiet. Type 8 (2).

Record 20. Croaking spontaneously. Electrode: middle lft. tectum. The first two thirds of the record is negative. The last third shows the scattered single throws of 10 mm. which form into a short series at the end of the record. Type 8 (2).

Record 21. Animal croaking spontaneously. Electrode: mid. lft. tectum. The first of the record shows a short series of 10 mm. throws and a few scattered single 10 mm. throws. Type 8 (2).

Record 22. Punched animal's right eye with pencil. Animal blinked. Electrode: mid. lft. tectum. The first third of the record shows one throw of 7 mm. At the beginning of the second third there is an abrupt series of 22 mm. amplitude, which tapers off rather abruptly and then is followed by a short series of 7 mm. amplitude. The last half of the record is negative. Type 4 (4).

Record 23. Punched animal's left eye with pencil. Animal blinked and jumped slightly. Electrode: rt. thalamus. The first 50 mm. of the record is quiet. At the end of this section there is an abrupt series of 22 mm. amplitude which decreases in amplitude to irregular 15 and 10 mm. throws. The last half of the record is quiet. Type 5 (4).

Record 24. Punched leg with pencil. Animal tried to flex leg and struggled vigorously. Electrode: post. rt. forebrain. The record is highly active throughout. In the first third the amplitude is 30 mm. The last two thirds shows uniformally 12 to 20 mm. amplitude. The throws are all fast. Type 10 (4).

Record 25. Punched leg with pencil. Animal tried to flex leg and struggled vigorously. Electrode: mid. lft. tectum. The record starts with an extended series which reaches a maximum of 35 mm. amplitude. This lasts for the first third of the record. The last two thirds of the record show more irregular activity which reaches 18 mm. and runs as low as zero in short places. The record, however, is active to the end. Type 11 (4).

Record 26. Punched leg of animal. Animal tried to flex leg and struggled vigorously. Electrode: mid. left tectum. The record is high throughout. In the first half of the record the amplitude runs to 40 mm. The last half shows amplitude

of 25 to 30 mm. The throws are all fast. Type 10 (4).

Record 27. Animal passive. Electrode: mid. lft. tectum. The record is negative. Type 1 (0).

Record 28. Animal passive. Electrode: post. right forebrain. The record is negative. Type 1 (0).

Record 29. Animal passive. Electrode: mid. left forebrain. The record is negative. Type 1 (0).

Record 30. Punched right eye of animal with pencil. Animal blinked. Electrode: lft. thalamus. The first third of the record shows series of 25 mm. maximum amplitude. This tapers off gradually into 15 mm. and 10 mm. throws. The onset of the series is very abrupt. The last half of the record is negative. Type 4 (4).

Record 31. Punched left eye of animal with pencil. The animal blinked. Electrode: middle thalamus. The first 50 mm. of the record is quiet. At the end of this time there occurs an abrupt series which reaches 23 mm. amplitude and then tapers off into 12 mm. amplitude before returning to the base line. The last half of the record is quiet. Type 5 (4).

Record 32. Animal passive. Electrode: lft. thalamus. The record is negative. Type 1 (0).

Record 33. Animal struggling spontaneously. Electrode: lft. thalamus. The record shows a series which reaches 20 mm. in amplitude. It is, however, irregular. Type 11 (4).

(2). Relation Between Stimulus-Response Situations and Records - The same three variables appear in these records as for the crayfish: the stimulus, the response of the animal, and the electrode position. From the 336 records obtained on the frog, there were 14 stimulus-response situations with sufficient distribution of data to warrant description.

Prior to the discussion of these behavior situations in detail a brief resume of the alleged functions of the various portions of the amphibian brain will be given. The anterior forebrain appears to be largely olfactory in function (Papez (30)), the middle forebrain is visual and perhaps auditory

(Papez (30)), the posterior forebrain is visual, olfactory and motor (Herrick (23)(24), Papez (30)). The forward portion of the middle thalamus is motor (Papez (30)) and the left and right are visual (Papez). The lateral tectum is auditory and visual, while the middle tectum is visual (Papez). The cerebellum is visual, auditory and motor (Papez). In connection with the internal structure of the amphibian brain Herrick (24) remarks that the equipotential structure of the brain "obviously favors total reactions or mass reflexes (p.281)".

(a). Animal Passive in the Room Light: The first behavior situation to be discussed is that of the animal passive in the regular illumination of the room. Table XII shows the data for this situation with the electrode positions, the record types, and the average magnitude for each region.

Table XII.

Brain Position	Record Type	Average Magnitude
Rt. ant. fore.	8, 1	1.0
Rt. mid. fore.	1, 1	0
Rt. post. fore.	1, 13, 1	.33
Ant. rt. and lft. fore.	1, 1	0
Lft. ant. fore.	1, 1, 1, 1	0
Lft. mid. fore.	8, 1, 1	.66
Lft. post. fore.	1, 1	0
Post. rt. and lft. fore.	1, 1	0
Mid. thalamus	1, 9	1.0
Lft. thalamus	1	0
Rt. mid. tectum	1, 1, 13	.33
Rt. lat. tectum	13, 1	.5
Lft. mid. tectum	1, 1, 5, 1	1.0
Lft. lat. tectum	6	2.0
Rt. cerebellum	1	0
Lft. cerebellum	1	0
	35 Records	Average .42

The data from Table XII also appear in Plate XI, figure 1. It will be noted from an examination of this plate that

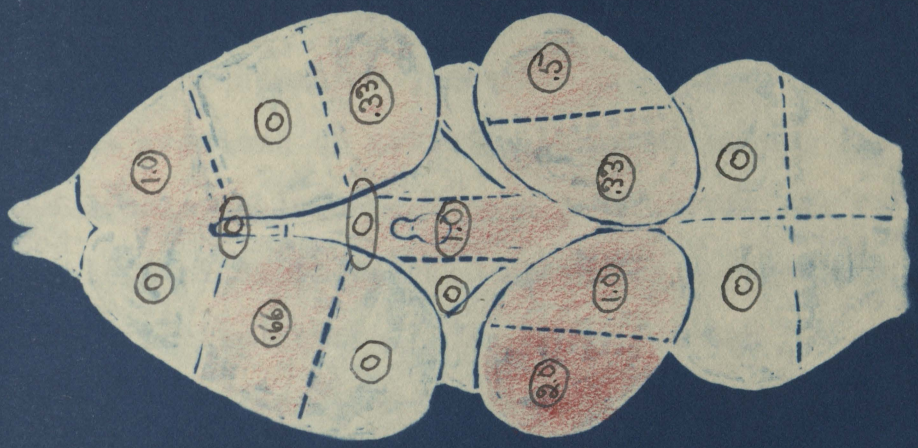

fig. 1

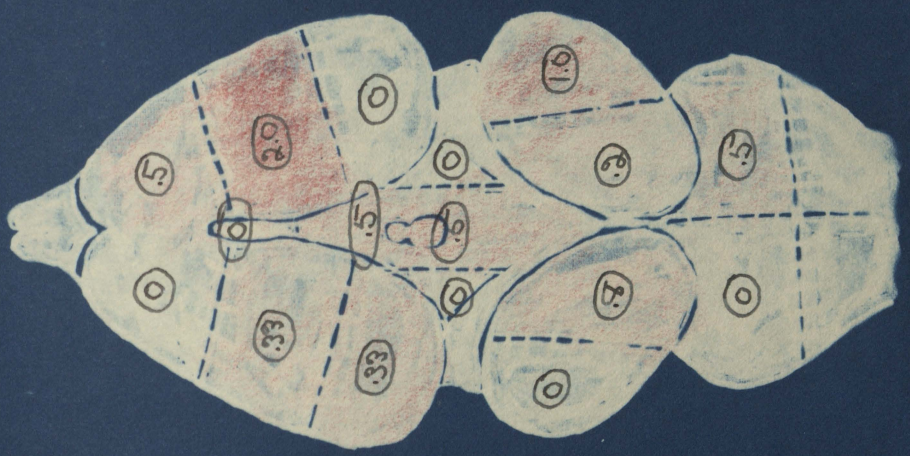

fig. 2

PLATE XI

there is a medium peak in the left lateral tectum which, supposedly, has a visual and auditory function. The thalamus (mid) and the right anterior forebrain are slightly active. In general the gradient of activity seems to occupy the tectum and the middle thalamus and to a less extent the forebrain. The left middle forebrain which has a visual function is very slightly active. The gross average for all the records is .42 for this condition: room light with the animal passive.

(b). Animal Passive in the Dark. The next situation is animal passive in the absence of the room light. The results are presented in Table XIII.

Table XIII.

Brain Position	Record Type	Average Magnitude
Rt. ant. fore.	1, 13	.5
Rt. mid. fore.	8	2.0
Rt. post. fore.	1, 1	0
Ant. rt. and lft. fore.	1, 1	0
Lft. ant. fore.	1	0
Lft. Mid. fore.	1, 13, 1	.33
Lft. post fore.	1, 12, 1	.33
Post. rt. and lft. fore.	13, 1	.5
Rt. thalamus	1	.0
Mid. thalamus	1, 13	.5
Lft. thalamus	1	0
Rt. mid. tectum	1, 1, 1, 8, 1	.2
Rt. lat. tectum	13	1.0
Lft. mid. tectum	12, 1, 8-	.8
Lft. lat. tectum	1, 1	0
Rt. cerebellum	1, 12	.5
Lft cerebellum	1, 1	0
	35 Records	Average .39

The data from the above table are shown again in Plate XI, figure 2. A peak occurs in the right middle forebrain which is supposedly auditory and visual in function. Another

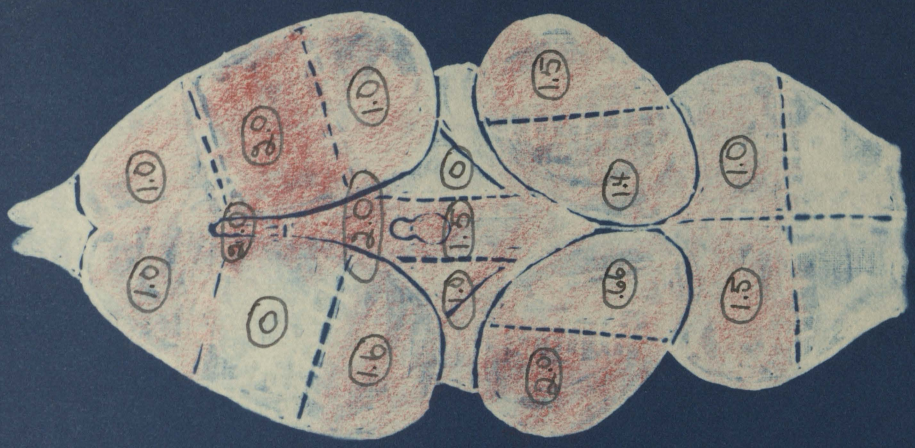

fig. 1

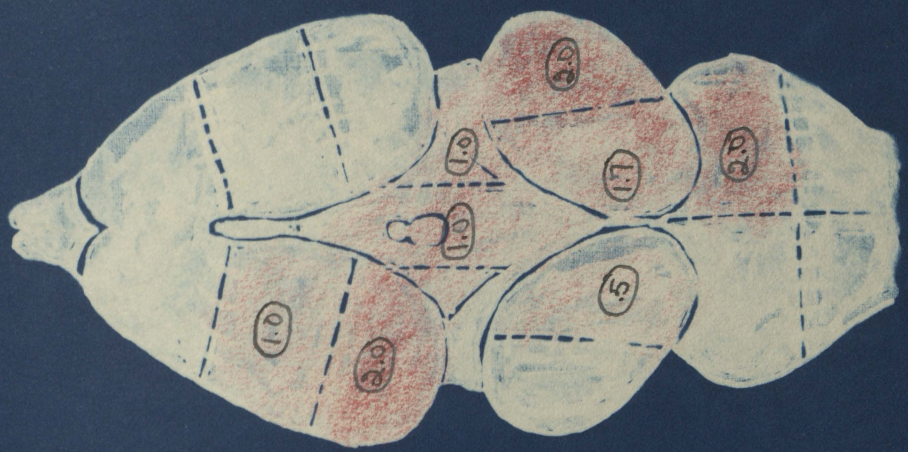

fig. 2

PLATE XII

slight peak occurs in the right lateral tectum which is said to be auditory. In general the gradient appearing in this map is unlike that under the room light condition in that the forebrain is slightly more active. However, the energy level is lower than that under the room light condition. The gross average for darkness is .39 as compared with .42 under room light.

(c). Animal Passive with Flashlight in Eye. In this behavior situation a definite visual stimulus was given the animal. The light was flashed into the animal's right eye, but the animal remained passive. The data appear in Table XIV.

Table XIV.

Brain Position	Record Type	Average Magnitude
Rt. ant. fore.	13	1.0
Rt. mid. fore.	8	2.0
Rt. Post. fore.	13	1.0
Ant. rt. and lft. fore.	8	2.0
Lft. ant. fore.	13	1.0
Lft. mid. fore.	1, 1	0
Lft. post. fore.	8, 8, 13	1.6
Post. rt. and lft. fore.	8, 8	2.0
Rt. thalamus	1	0
Mid. thalamus	8-	1.5
Lft. thalamus	12	1.0
Rt. mid. tectum	1, 8, 8, 13,8	1.4
Rt. lat. tectum	8-	1.5
Lft. mid. tectum	12, 13, 1	.66
Lft. lat. tectum	8	2.0
Rt. cerebellum	12, 13	1.0
Lft. cerebellum	8-, 8-	1.5
	29 Records Average	1.24

The data from Table XIV are transferred to Plate XII, figure 1. There are four peaks of medium amplitude. Three of these are in the middle and across the forebrains, which are assigned a visual and auditory function. The other is

in the left lateral tectum, which is also visual and auditory. It will be noted that there is a diagonal gradient extending from the right middle forebrain to the left lateral tectum. It is noteworthy that the cerebellum appears as slightly active. The appearance of the gradient is much the same as that occurring under darkness except that the level of activity is raised and the intent of the gradient is widened. It is significant that the flashlight stimulus was given on the right side of the animal, which the gradient starts in the tectum on the left side and then crosses to the right through the thalamus. The gross level of magnitude for all the records under the flashlight is 1.24 as compared with .42 when the animal is in room light and .39 when the animal is in total darkness.

(d). Animal Passive With Flickering Light in Eye. The next of the visual behavior situations is that of the animal passive while the flashlight was turned on three times directly into the animal's eyes. The data are given in Table XV.

Table XV.

Brain Position	Record Type	Average Magnitude
Lft. mid. fore.	8, 1	1.0
Lft. post. fore.	9	2.0
Mid. thalamus	12	1.0
Lft. thalamus	12	1.0
Rt. mid. tectum	12, 8, 4, 1	1.7
Rt. lat. tectum	8	2.0
Lft. mid. tectum	12, 1	.5
Rt. cerebellum	8, 8	2.0
	14 Records Average	1.40

The data of this table show, again, in Plate XII, figure 2. While the data are incomplete, peaks show in the left posterior forebrain, of olfactory and motor function, in the right lateral tectum, of visual and auditory function, and in the right cerebellum. It will be noted that a diagonal gradient extends from the left posterior forebrain through the right tectum and into the cerebellum. This gradient is the reverse to that found under the single flashlight stimulus. The cerebellum in this case becomes moderately active with the tectum and forebrain. The gross average for this situation with the flickering light is 1.40 as compared with 1.24 with the single flashlight, .42 with the animal passive in the room light and .39 with the animal in total darkness.

(e). Animal Passive When Hit Leg or Back or Pulled Leg. This is the first of the situations which involves tactual stimulation. The animal remained passive while the experimenter hit its back or legs or while the cord, attached to the legs, was pulled. The data are given in Table XVI, and in Plate XIII, figure 1. The number of areas explored in this situation is few, but certain points can be discussed. There are peaks of medium amplitude in the left middle forebrain which is visual and auditory in function, and in the right posterior forebrain, which is motor and olfactory in function. Very slight activity occurred in the right middle tectum, which is visual in function. The activity of the 'visual regions' under this condition can probably be accounted for by the fact that the room light was on and thus the animal was receiving visual stimulation. A level of 1

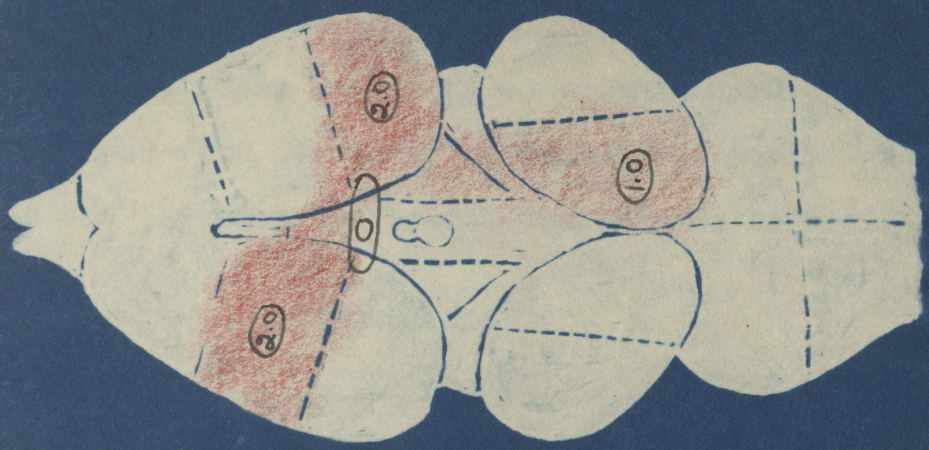

fig. 1

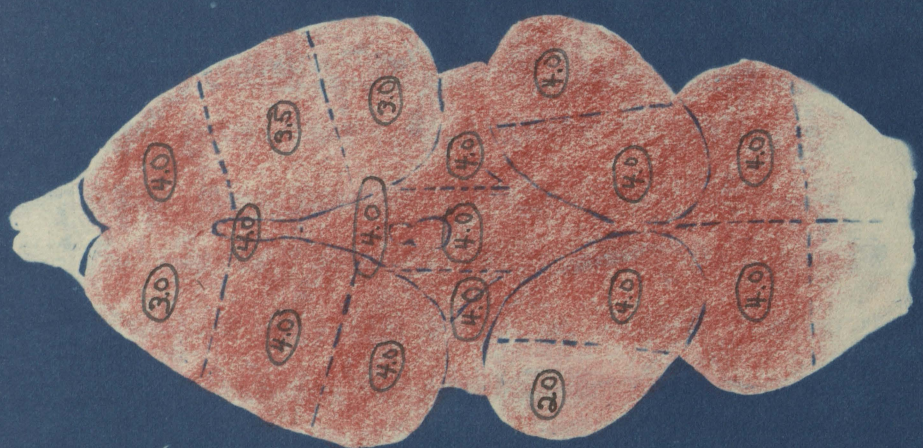

fig. 2

PLATE XIII

was reached in the present situation and an average of 1.2 for the tectum in passive to room light. The gross average amplitude for the areas explored, under this condition, was 1.25 as compared with .42 when the animal was passive in the room light and .39 when the animal was passive in darkness.

Table XVI.

Brain Position	Record Type	Average Magnitude
Rt. post. fore.	8	2.0
Lft. mid. fore.	9, 9	2.0
Post. rt. and lft. fore.	1	0
Rt. mid. tectum	12	1.0
	5 Records	Average 1.25

(f). Animal Winced or Stiffened When Punched Back or Body. In this case the animal made a definite response to the tactual stimulation: the experimenter punching the animal's back or body. The data appear in Table XVII and in Plate XIII, figure 2. It will be noted that the brain is highly active, throughout, under this condition. The areas of maximum magnitude include the olfactory, visual, auditory and motor. The area of lowest magnitude, which is moderately active, is the left lateral tectum, which is supposedly auditory in function. In general the gradient shows greatest activity in the left side of the forebrain; all of the thalamus is highly active, also the right and middle aspect of the tectum, and the cerebellum. The gross average for this condition is 3.63 as compared with 1.25 when the animal received tactual stimulation but was passive, and with .42 when the animal was passive in the dark.

Table XVII.

Brain Position	Record Type	Average Magnitude
Rt. ant. fore.	11	4.0
Rt. mid. fore.	11, 9+	3.5
Rt. post. fore.	5-	3.0
Ant. rt. and lft. fore.	11	4.0
Lft. ant. fore.	8, 11	3.0
Lft. mid. fore.	11, 10	4.0
Lft. post. fore.	11, 11, 11	4.0
Post. rt. and lft. fore.	5, 11	4.0
Rt. thalamus	11	4.0
Mid. thalamus	11, 10	4.0
Lft. thalamus	5	4.0
Rt. mid. tectum	11, 11, 5, 11	4.0
Rt. lat. tectum	11	4.0
Lft. mid. tectum	11, 10, 11	4.0
Lft. lat. tectum	9, 8	2.0
Rt. cerebellum	11, 11	4.0
Lft. cerebellum	11, 11	4.0
	32 Records	Average 3.63

(g). Animal Struggled or Winced When Leg Was Hit or Punched. In this situation the animal either struggled or winced rather vigorously when the experimenter hit or punched its leg with the pencil. The data are in Table XVIII and Plate XIV, figure 1. Examination of the figure shows that the brain of the frog was almost uniformally active at the maximum level of amplitude. The lowest level of activity occurred in the left anterior forebrain, but this is above medium activity. The tectum and the explored portions of the thalamus are all maximum. In general there seems to be a concentration of maximum activity in the medial aspect of the brain. The gross average for this condition was 3.88 as compared with 3.63 when the animal winced and stiffened as its back or body was punched, and 1.25 when the animal was passive under tactual stimulation.

fig. 1

fig. 2

PLATE XIV

Table XVIII.

Brain Position	Record Type	Average Magnitude
Rt. ant. fore.	4, 10	4.0
Rt. mid. fore.	10,10,11,8	3.5
Rt. post. fore.	11,10,10, 4, 11,10	4.0
Ant. rt. and lft. fore.	10,10	4.0
Lft. ant. fore.	11, 8	3.0
Lft. mid. fore.	5,5	4.0
Lft. post. fore.	10,4,10,5	4.0
Post. rt. and lft. fore.	11	4.0
Mid. thalamus	10,5	4.0
Rt. mid. tectum	10,10	4.0
Rt. lat. tectum	5,11	4.0
Lft. mid. tectum	11,10,4	4.0
Lft. lat. tectum	11	4.0
	33 records	Average 3.88

(h). Animal Draws Up Legs and Struggles When Pulled Cord on Legs. In this situation the experimenter flexed and extended the animal's legs by pulling the cord attached to the legs. The animal flexed its legs and struggled. The data are in Table XIX and Plate XIV, Figure 2. Most of the areas explored show maximum amplitude. These include the middle tecta, the middle thalamus, the middle forebrains, anterior forebrains, and the right posterior forebrain. The left posterior forebrain and the right middle forebrain are moderately active. It will be noted that a definite medial-line-gradient appears, which is in many respects similar, but not as extended as the gradient under (g). The gross average magnitude under the present condition was 3.20 as compared with 3.88 under (g) and 3.63 under (f).

(i). Animal Struggled Spontaneously. Under this condition the animal received no experimental stimulation but struggled

Table XIX

Brain Position	Record Type	Average Magnitude
Rt. ant. fore.	11	4.0
Rt. mid. fore.	9	2.0
Rt. post. fore.	11, 10, 10	4.0
Ant. rt. and lft. fore.	4, 11, 5	4.0
Lft. ant. fore.	11	4.0
Lft. post. fore.	9	2.0
Post. rt. and lft. fore.	10, 11, 11,5	4.0
Mid. thalamus	10, 5	4.0
Rt. mid. tectum	11, 11, 11	4.0
Lft. mid. tectum	11, 11	4.0
	21 Records Average	3.20

spontaneously. The struggling included stiffening and raising of the body, vigorous moving of the legs, and general body movement. The data collected under this condition are presented in Table XX and Plate XV, figure 1. Although the data are incomplete, they warrant certain conclusions. The majority of the regions explored are maximum in amplitude. These include all of the thalamus, the middle portions of the forebrain, the left anterior and the right middle forebrain.

Table XX.

Brain Position	Record Type	Average Magnitude
Rt. mid. fore.	11, 11	4.0
Rt. post. fore.	8	2.0
Ant. rt. and lft. fore.	11, 4, 11	4.0
Lft. ant. fore.	11	4.0
Post. rt. and lft. fore.	11	4.0
Rt. thalamus	10	4.0
Mid. thalamus	10, 10, 4	4.0
Lft. thalamus	11	4.0
Lft. mid. tectum	10, 8	3.0
	15 Records Average	3.66

The moderately active regions are the posterior right fore-

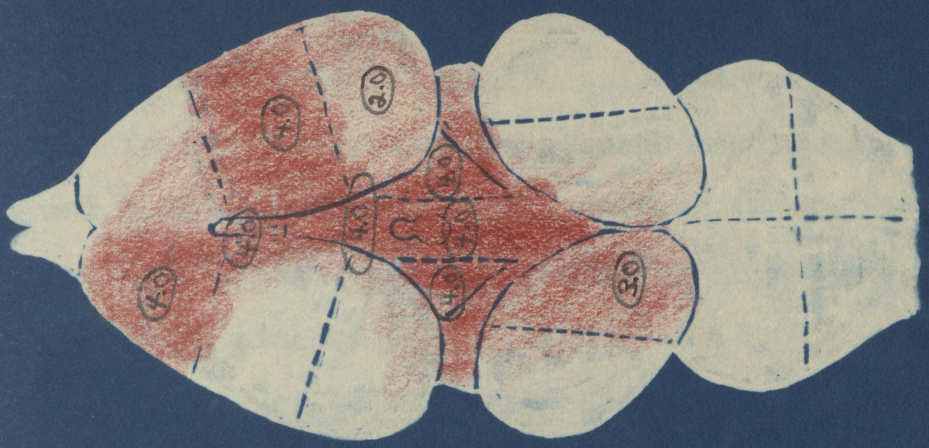

fig. 1

fig. 2

PLATE XV

brain and the left middle tectum. In this case there is also a medial gradient, with its posterior peak in the thalamus shading off gradually into the tectum and less gradually into the posterior forebrain. The gross average magnitude for this condition was 3.66 as compared with 3.20 when the animal struggled and drew up its legs, and 3.88 when the animal struggled with its leg hit or pinched.

(j). Animal Struggled Violently When HCl Was Placed on Skin. This situation furnishes a definite pain stimulus, to which the animal responded by struggling violently. The data appear in Table XXI and Plate XV, figure 2. The areas studied

Table XXI.

Brain Position	Record Type	Average Magnitude
Rt. post. fore.	10	4.0
Lft. mid. fore.	10	4.0
Mid. thalamus	10	4.0
Rt. mid. tectum	10	4.0
	4 Records	Average 4.0

are all active to a maximum. These include the left middle forebrain, the right posterior forebrain, the middle thalamus, and the right middle tectum. Thus visual, olfactory, motor and auditory regions seemed to be involved under response to pain situation, as was also true in situations g, h and i. The gross average magnitude of all the records taken under this situation is 4.00, as compared with 3.66 under spontaneous struggling, and 3.88 when the animal struggled to hitting and pinching stimulation.

(k). Animal Blinked or Closed Eyelid When Punched Right Eye. The next behavior situation to consider is that of punching the right eye, to which the animal responded by blinking or closing its eyelid. This overt response shows only as a local movement, involving only the eye and eyelid. The animal did not visibly wince or jump. The data are given in Table XXII and Plate XVI, figure 1. The brain was very highly active

Table XXII.

Brain Position	Record Type	Average Magnitude
Rt. ant. fore.	5	4.0
Rt. mid. fore.	5, 11	4.0
Rt. post. fore.	5, 11	4.0
Ant. rt. and lft. fore.	5	4.0
Lft. ant. fore.	5, 11	4.0
Lft. mid. fore.	8, 11	3.0
Lft. post. fore.	5, 11	4.0
Post. rt. and lft. fore.	4, 10	4.0
Rt. thalamus	5	4.0
Mid. thalamus	5, 5	4.0
Lft. thalamus	4	4.0
Rt. mid. tectum	5, 9	3.0
Rt. lat. tectum	11	4.0
Lft. mid. tectum	5, 11, 4	4.0
Lft. lat. tectum	2	4.0
Rt. cerebellum	5	4.0
Lft. cerebellum	11	4.0
	27 Records Average	3.88

throughout under this behavior situation. There are points slightly below maximum in the left middle forebrain and the right middle tectum. Note that all the thalamus is maximum, as well as the cerebellum. The gross average magnitude in this situation was 3.88 as compared with 1.25 when the animal was passive and 3.88 when the animal struggled after having its leg hit or pinched. The wide, high distribution

fig. 1

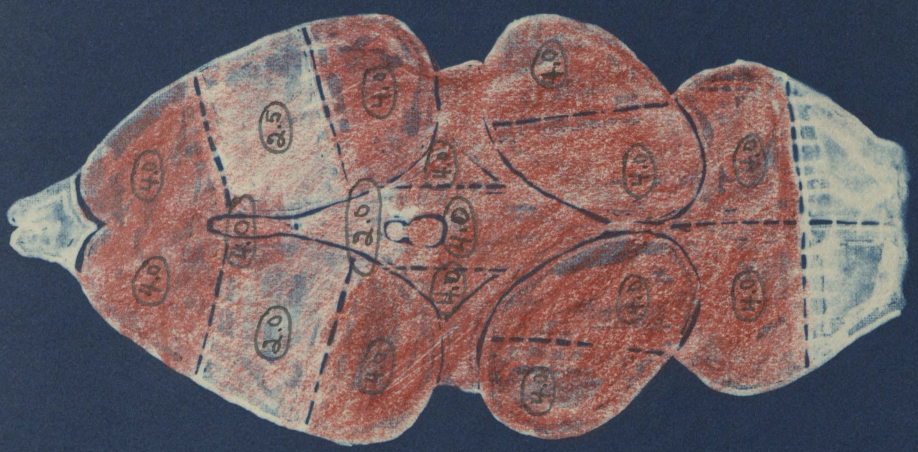

fig. 2

PLATE XVI

found when the animal winked seems to indicate the large amount of brain tissue involved in a supposedly simple reflex, and justifies a special discussion, later.

(l). Animal Blinked or Closed Eyelid When Punched Left Eye. This situation is the same as (k) except that the animal's left eye was punched with the pencil instead of the right eye. The animal merely blinked or closed its eyelid. The data from this condition are shown in Table XXIII and Plate XVI, figure 2. Again the energy disturbance is maximum

Table XXIII.

Brain Position	Record Type	Average Magnitude
Rt. ant. fore.	4	4.0
Rt. mid. fore.	5, 13	2.5
Rt. post. fore.	5, 5	4.0
Ant. rt. and lft. fore.	5, 5	4.0
Lft. ant. fore.	5, 4	4.0
Lft. mid. fore.	8	2.0
Lft. post. fore.	11, 11	4.0
Post. rt. and lft. fore.	8	2.0
Rt. thalamus	5	4.0
Mid. thalamus	11, 5	4.0
Lft. thalamus	5	4.0
Rt. mid. tectum	5, 5	4.0
Rt. lat. tectum	11	4.0
Lft. mid. tectum	4, 5	4.0
Lft. lat. tectum	5	4.0
Rt. cerebellum	5, 5	4.0
Lft. cerebellum	5	4.0
	26 Records	Average 3.67

almost throughout as when the right eye was punched. In this case there is a band of moderately active regions in the forebrain, also in the left and right middle forebbain and at the boundary of both right and left forebrain at the posterior end. It will be noted that one of these regions is the same as ap-

peared relatively low in the right eye situation. In this case all the cerebellum, the tecta, and the thalamus are maximum. Examination of the tables for this situation and for (k) show that there is a predominance of records of types 4 and 5. It will be remembered that these types are large in amplitude, irregular and intermittent. Type 4 is short in duration and type 5 is longer in duration. These were typical responses under the condition of punching the eye. There was either a long or short train of impulses, usually abrupt in onset, and gradual in tapering off. The average magnitude for all the records under this condition was 3.67 as compared with 3.88 when the right eye was punched.

(m). Animal Winced Slightly When Rubbed Back. In this case the response of the animal:a slight wincing while the experimenter rubbed the animal's back with the rubber end of the pencil. The data, incomplete, are shown in Table XXIV and

Table XXIV.

Brain Position	Record Type	Average Magnitude
Rt. mid. fore.	9	2.0
Rt. post. fore.	10, 5	4.0
Lft. ant. fore.	11	4.0
Lft. mid. tectum	8	2.0
	5 Records	Average 3.0

Plate XVII, figure 1. The map shows a peak of maximum amplitude in the left anterior forebrain, and another in the right posterior forebrain. The middle forebrain and the left middle tectum show medium activity. The gross average of this behavior situation is 3.00

fig. 1

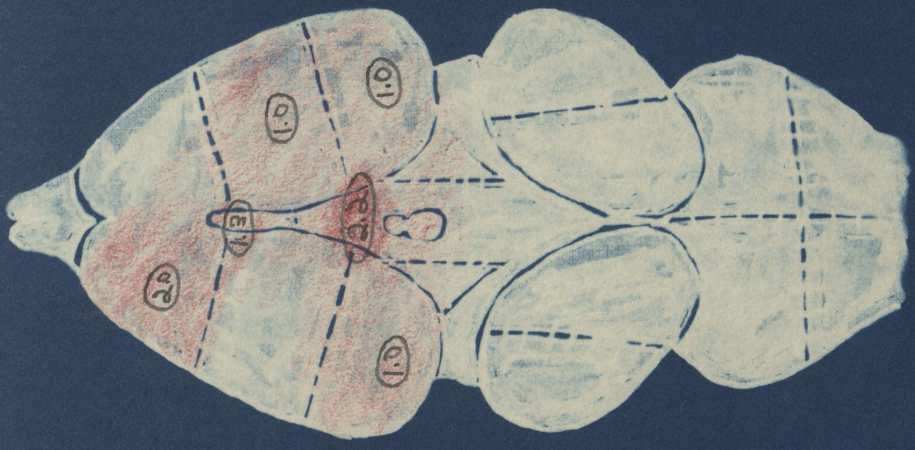

fig. 2

PLATE XVII

(n). Animal Passive Under Sound Stimulation. In this situation the animal was passive to various sound stimuli, which included a 1024 d.v. quincke tube, 325, 387 and 488 d.v. tuning forks, a d-major harmonica and a Galton whistle. Table XXV and Plate XVII, figure 2 show the results. Although

Table XXV.

Brain Position	Record Type	Average Magnitude
Rt. mid. fore.	13, 13	1.0
Rt. post. fore.	1, 6, 13	1.0
Ant. rt. and lft. fore.	9, 8-, 13, 8, 13	1.3
Lft. ant. fore.	1, 4, 9	2.0
Lft. post. fore.	13	1.0
Post. rt. and lft. fore.	8-, 9, 5, 8, 8-	2.2
	19 Records Average	1.41

we did not succeed in catching the animal passive, on all the available electrode positions there was sufficient exploration of the forebrain to warrant certain conclusions. The boundary of the posterior right and left forebrain contains the largest peak which is only medium. This borders on the auditory region of the forebrain. The left anterior forebrain is also medium. The other regions explored, which include visual, olfactory, motor and the rest of the auditory region, are all slightly active. The gross average for this situation is 1.41 as compared with .39 when the animal was passive in the dark and 1.24 when the animal was receiving flashlight stimulation.

(3). Conclusions on the Amphibian. The data just presented on the frog can be summarized under six heads: light stimulation; tactual stimulation with the animal passive; tac-

tual stimulation with the animal passive; tactual stimulation with the animal responding; pain stimulation with the animal responding; spontaneous activity of the animal; and auditory stimulation.

(a). Light Stimulation. In situation (b), darkness and passive, there occurred a low amplitude gradient which showed small peaks in the visual and auditory region. The forebrain was fairly active. The average magnitude for this condition was .39. When the room light was turned on, situation (a), there was an increase in the level of the gradient, but a slight decrease in the activity of the forebrain. The moderately active peaks included the visual and auditory regions. In general the two gradients are similar but that under room light is higher in level. The gross average under room light was .42 as compared with .39 when the animal was in the dark. In situation (c), when a definite visual stimulus was given the animal by flashing a light, there is a further rise in the level of the gradient, and an extension of the range over a wider area. The appearance of a diagonal gradient, in this case, is probably correlated with the crossing of the optic tracts. In this case, also, the cerebellum appears slightly active. The gross average in this case was 1.24 as compared with .42 with room light and .39 with darkness. The two light conditions, flashlight and room light, give a gross average of .83. When the animal was given a flickering light, (d), there is again a general rise in the level of the gradient, but the direction of the gradient is diagonal in the opposite direc-

tion to that of (c). The cerebellum and the tectum become more active than with a single flashlight. In this case the gross average is 1.40 as compared with 1.24 under the flashlight. The gross average of flashlight and flicker is 1.32, while an average of all light stimulation gives 1.02. Recall that, under darkness, it was .39.

(b). Passive with Tactual Stimulation. There is but one situation in this group (e) where the animal's leg or back was hit or the cord attached to the animal's leg was pulled, in which the animal was passive. There is medium activity under this condition in the visual, olfactory, auditory and motor regions. The gross average, under this condition, was 1.25 as compared with .39 with the animal in the dark and 1.02 with light stimulation.

(c). Animal Active Under Tactual Stimulation. There are five situations in this group. The first, (f), is when the animal winced or stiffened as its back or body was punched. The gradient covers all regions with medium to maximum activity, with slightly greater activity on the left side of the forebrain. The gross average for this condition is 3.63. In (h) the animal drew its legs up and struggled when the cord, attached to them, was pulled. Again, most of the regions explored show maximum activity, but in this case a medial-line gradient appears. In this case the gross amplitude average was 3.20. In the next condition, (k), the animal blinked when its right eye was punched. The brain in this case is practically uniform at a maximum level of magnitude. The gross average is 3.88. In situation (l), blinking of the animal

when the left eye was punched, there is a very slight reduction in the gradient, but most of the regions are uniformally active at a maximum. The gross average in this case was 3.67. The last situation, (m), was where the animal winced slightly when its back was rubbed. The gradient in this case is not complete, but shows two definite peaks in the forebrain,in the olfactory and motor regions. The gross average in this case is 3.00. A gross average has been calculated for the conditions in which the animal was active to tactual stimulation, which gives 3.47 as compared with 1.25 with the animal passive under tactual stimulation, 1.02 with light stimulation, and .39 with darkness. The significant feature of this group of results, as compared with the preceding, seems to be a high homogeneous level of activity.

(d). Animal Active Under Pain Stimulation. There are two situations in this grouping of the data. In the first, the animal struggled and winced when its leg was hit or pinched (g). Again the brain is almost homogeneously active at a maximum level. All of the regions are above medium level activity. The gross average in this case was 3.88. In the other situation (j) HCl was placed upon the skin, to which the animal responded by struggling violently. In this case all of the regions explored are active at a maximum. The gross average in this case is 4.00. The average of these two situations is 3.94 as compared with 3.47 when the animal was active to tactual stimulation, 1.25 when the animal was passive to tactual stimulation, and .39 when the animal was passive in the dark.

(e). Animal Spontaneously Struggled. There is one situation, under this heading (i), in which the animal struggled without stimulation by the experimenter. Almost all of the areas explored show maximum activity. In this case the medial gradient appears again which has a posterior peak in the thalamus, tapering off steeply in a posterior direction and gradually in an anterior direction. The gross average in this case was 3.66 as compared with 3.94 under pain, 3.47 when the animal was active to tactual stimulation, 1.25 when the animal was passive to tactual stimulation, and .39 when the animal was passive in the dark.

(f). Auditory Stimulation. Under this condition, (n), the animal remained passive while various types of auditory stimuli were given it. The highest activity is only medium and occurs in the auditory, visual and olfactory regions. The gross average for this situation is 1.41 as compared with the average of 1.32 under definite visual stimulation, 1.25 with the animal passive under tactual stimulation, 3.47 when the animal was active under tactual stimulation, 3.94 when the animal was under pain stimulation, and .39 when the animal was passive in the dark.

V. THE REPTILE.

(1). Description of Experiments and Records - Only two experiments were performed on the Reptile, a bull snake, in which 39 records were secured. Plate XVIII shows a diagram of the snake's brain in which the arbitrary regions, used to locate the electrodes, are indicated. The figure also contains circles which show the letters of the experiments, marking the electrode positions used in the experiments.

Bull Snake V May 24, 9:00 p.m.

Description of Records:

Record 1. Animal quiet. Electrode posterior rt. forebrain. The record is negative with slight irregularity. Type 1 (0).

Record 2. Animal quiet. Electrode: posterior lft. forebrain. The record is negative. Type 1 (0).

Record 3. Lost.

Record 4. Tapping head three times. Animal winced and writhed slightly. Electrode: posterior rt. forebrain. The record shows three definite but small groups of throws. These are interspersed with smaller, doubtful throws. The large groups are on the average, 8 mm. in height, but are short in duration. Type 6 (2).

Record 5. Tapping head three times. Animal winced and writhed slightly. Electrode: posterior lft. forebrain. The record shows three short groups of throws which are interspersed throughout the record with smaller irregularities of about 5 mm. amplitude. The larger throws are 10 mm. in height. Type 8 (2).

Record 6. Pinched body. Slight writhing. Electrode: posterior lft. forebrain. The record shows irregular small throws scattered throughout the record. The largest of these throws are 5 mm. in height. Type 13 (1).

Record 7. Pinched body. No response. Electrode: posterior rt. forebrain. The record is negative. Type 1 (0).

Record 8. Punched pencil inside mouth. Animal struggled vigorously. Electrode: posterior rt. forebrain. Raised head slightly. The record shows one short series of throws at the very beginning which are 14 mm. in amplitude. These taper

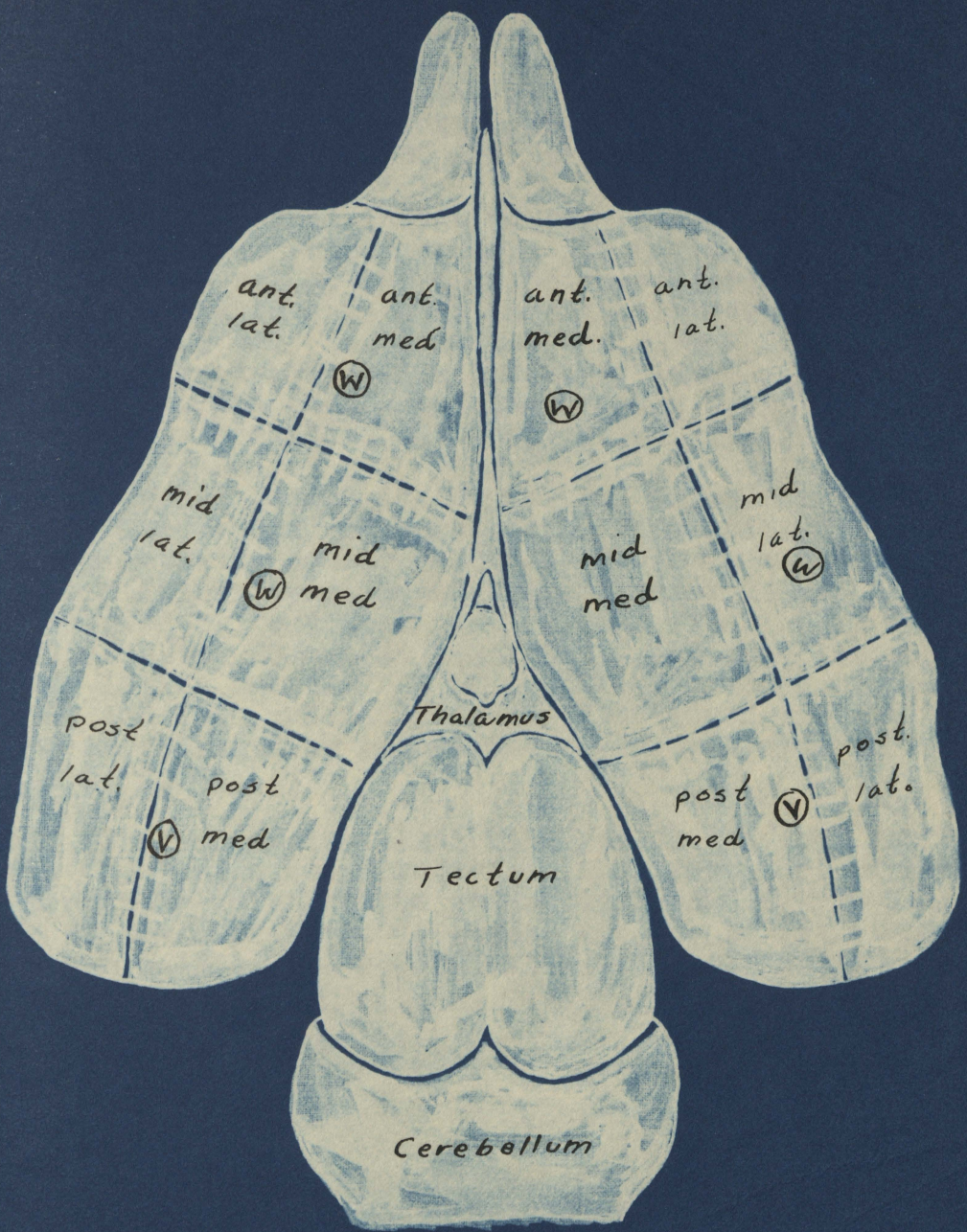
ant. lat.
ant. med
ant. med.
ant. lat.
W
W
mid lat.
mid med
mid med
mid lat.
W
W
Thalamus
post lat.
post med
V
post med
V
post. lat.
Tectum
Cerebellum

PLATE XVIII

off and are followed by smaller short series of 5 mm. in amplitude up to the middle of the record. At this point very large activity starts and extends for about a third of the record at which point it subsides abruptly to no activity. These large throws are very rapid and average 25 mm. in amplitude, ranging as high as 30 mm. in height. Type 10 (4).

Record 9. Punched pencil inside mouth. Animal struggled vigorously. Electrode: posterior lft. forebrain. This record is very similar to no. 8, showing the short series at the first of the record which in this case is slightly larger, giving an amplitude of 20 mm. In this case the series of extended activity starts gradually, with throws of 10 mm., reaches a maximum of 30 mm. and then subsides abruptly. The last third of the record is irregular, but very small. Type 10 (4).

Record 10. Punched pencil inside mouth. Animal struggled vigorously. Electrode: posterior lft. forebrain. This record shows activity somewhat similar to the two above. It starts with a fairly long series which reaches 25 mm. in height. This is followed by four small series, one of which is large but short, reaching 20 mm. in amplitude. Extended activity begins on the latter half of the record which reaches 25 mm. fairly abruptly and then gradually grades off toward the end of the record and is followed by one series of three throws of 15 mm. height. Type 11 (4).

Record 11. Punched inside mouth with pencil. Animal struggled. Electrode: posterior rt. forebrain. The first part of the record is irregular which shifts gradually into a fairly long series of 20 mm. amplitude. A second smaller series starts in the latter half of the record, with amplitude of 10 mm. Type 11 (4).

Bull Snake W May 26, 1933, 3:00 p.m.

Description of Records:

Record 1. Animal quiet. Electrode: mid. lat. rt. forebrain. The first part of the record is quiet, but from the middle onward there are three throws, which are fairly equally spaced and 10 mm. in amplitude. These throws are interspersed with smaller throws. Type 8 (2) minus.

Record 2. Animal quiet. Lft. ant. forebrain. Light on. Record is negative. Type 1 (1).

Record 3. Closed circuit. Negative. Type 1 (0).

Record 4. Open circuit fuzzy and regular throughout. Type 12 (1).

Record 5. Touching eye. Animal passive, no eye response. Electrode: mid. lat. rt. forebrain. Negative record. Type 1 (0).

Record 6. Writhing slightly. Electrode: mid. lat. rt. forebrain. Negative record. Type 1 (0).

Record 7. Writhing slightly. Electrode: lft. ant. forebrain. Record negative. Type 1 (0).

Record 8. Tapped head twice. Snake winced and writhed slightly. Electrode: lft. ant. forebrain. There are two groups of throws, one in the first third of the record and one in the last third of the record. The largest throws are 14 mm. and the size of the smaller about 9 mm. The second series is larger and more extended than the first. Type 7 (2).

Record 9. Tapped head four times. Moved and writhed. Electrode: mid. lat. rt. forebrain. The record shows four distinct groups of large throws which start large in amplitude and then gradually grade off. The record in between the groups is small in amplitude but rough. The largest throws of the first group are 20 mm. in amplitude, smallest 10 mm. Second group, largest 12 mm. and smallest 8 mm. Third group, largest 15 and smallest 8 mm. Fourth group, 14 mm. and 8 mm. This latter group is composed of two groups close together. Type 5 (4).

Record 10. Quincke tube. Electrode: mid. lat. rt. forebrain. Animal quiet. Record shows a single throw 5 mm. in amplitude. Type 1 (0).

Record 11. Quincke tube. Electrode: lft. ant. forebrain. Animal quiet. There are two types of single throws scattered throughout the record. The larger ones are slow and 12 mm. in amplitude. The smaller are fast and 8 mm. in amplitude. These two are irregularly spaced throughout. Type 8 (2).

Record 12. Touched tail. Writhed and wriggled. Electrode: left ant. forebrain. There are two types of throws on the record. The first are very slow and regular and are probably artifacts. Both are from 15 to 20 mm. in amplitude. These extend for 50 mm. of the record. The record is fairly quiet for about a third of the record following, with a few scattered small throws. At this point there occurs five of the earlier type of throws which are close together and much faster than before. The last fourth of the record has irregular throws of 10 mm. which are fast. Type 4 (4).

Record 13. Lost.

Record 14. Animal quiet. Electrode: mid. lat. rt. forebrain. Record negative. Type 1 (0).

Record 15. Tapped head twice. Animal winced and writhed. Electrode: mid. lat. rt. forebrain. Record shows two short series of throws, with the largest 15 mm. in amplitude. These are toward the first half of the record. They are followed by smaller throws of 8 mm. amplitude. Type 8 (2).

Record 16. Tapped head four times. Animal winced and writhed. Electrode: mid. lat. rt. forebrain. There are four groups of throws on the records, which range from 15 to 20 mm. in amplitude. The tracing between these groups is small but rough in character. The smaller throws in the groups range around 10 mm. in height. Type 4 (4).

Record 17. Tapped head twice. Animal winced and writhed slightly. Electrode: lft. anterior forebrain. Record shows two short series of small throws, with amplitudes of 8 and 10 mm. With the exception of these the record is quiet. Type 6 (2).

Record 18. Tapped head three times. Animal winced and writhed slightly. Electrode lft. ant. forebrain. The record shows three short series of throws. The first is the largest and has an amplitude of 15 mm. The others have amplitudes of 10 mm. The record is quiet between the series. Type 6 (2).

Record 19. Stroked body. Wriggled and writhed slightly. Electrode: lft. ant. forebrain. Record negative. Type 1 (0).

Record 20. Tapped head five times. Animal winced. Electrode: med.(mid) lft. forebrain. There are five small groups of throws, three of which are quite small, only 9 mm. in amplitude. They are also short, in two cases only two throws. The other two series are longer and are 12 mm. in amplitude. Type 6 (2).

Record 21. Tapped head six times. Slight wriggling and writhing. Electrode: med. anter. rt. forebrain. There are six small and short series on the record. They range from 8 to 10 mm. in height. Type 6 (2).

Record 22. Slight wriggling of body and tail. Electrode: med. ant. rt. forebrain. Record is negative. Type 1 (0).

Record 23. Hit body. Animal passive. Electrode: med. ant. rt. forebrain. Record is uniformly negative. Type 1 (0).

Record 24. Quincke tube. Animal passive. Electrode: med. ant. rt. forebrain. Record is uniformly negative. Type 1 (0).

Record 25. Quincke tube. Animal passive. Electrode: med. (mid) lft. forebrain. Negative. Type 1 (0).

Record 26. Quiet. Electrode: med. (mid) lft. forebrain. Negative. Type 1 (0).

Record 27. Pinched behind mouth on rt. side. Animal jumped and writhed. Electrode: med. (mid) lft. forebrain. Record shows two series of throws of large amplitude; the first starts at 40 mm. in height and then tapers off. The second series, which is really a continuation of the first is 70 mm. in duration and about 15 mm. in amplitude. Type 5 (4).

Record 28. Pinched behind mouth on rt. side. Jumped and writhed. Electrode: med. ant. rt. forebrain. Record showed a long series of impulses which extend for the first 80 mm. of the record. These throws are 15 mm. in amplitude, regular and fast. Type 5 (4).

Record 29. Animal struggled spontaneously. Electrode: med. ant. rt. forebrain. The first half of the record is rough, showing very small, irregular throws. The last half of the record is uniformly active and very regular. The throws are, on the average, 15 mm. in height. Gradually toward the very end of the record the activity subsides. Type 10 (4).

Record 30. Animal struggled and writhed. Electrode: med. ant. rt. forebrain. The beginning of the record shows a series of throws of 15 mm. in height, but these last for only 25 mm. The rest of the record is irregular with small throws of 5 mm. Type 4 (4).

(2). Relation Between Stimulus-Response Situations and Records.- From the 39 records obtained on the snake, there were 7 behavior situations with sufficient data to warrant brief descriptions. The anterior medial and lateral forebrain and the medial lateral forebrain are ascribed an olfactory function by Papez (30). The middle median forebrain has a visual function, while the entire posterior forebrain is motor (Papez 30). The middle lateral forebrain is also a general somatic region (Papez 30).

(a). Animal Passive in the Room Light. In this situation the animal was passive with no stimulation except the ordinary room illumination. The data are in Table XXVI and Plate XIX, figure 1.

Table XXVI.

Brain Position	Record Type	Average Magnitude
Rt. mid. lat. fore.	8-,1	.7
Rt. post. fore.	1	0
Lft. fore.	1	0
Lft. mid. med. fore.	1, 1	0
Lft. post. fore.	1	0
	7 Records	Average .14

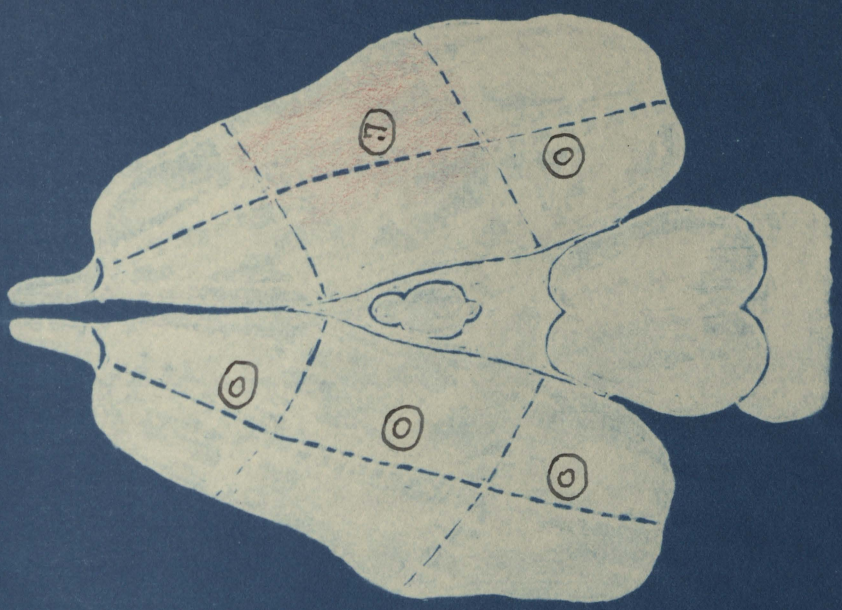

fig. 1

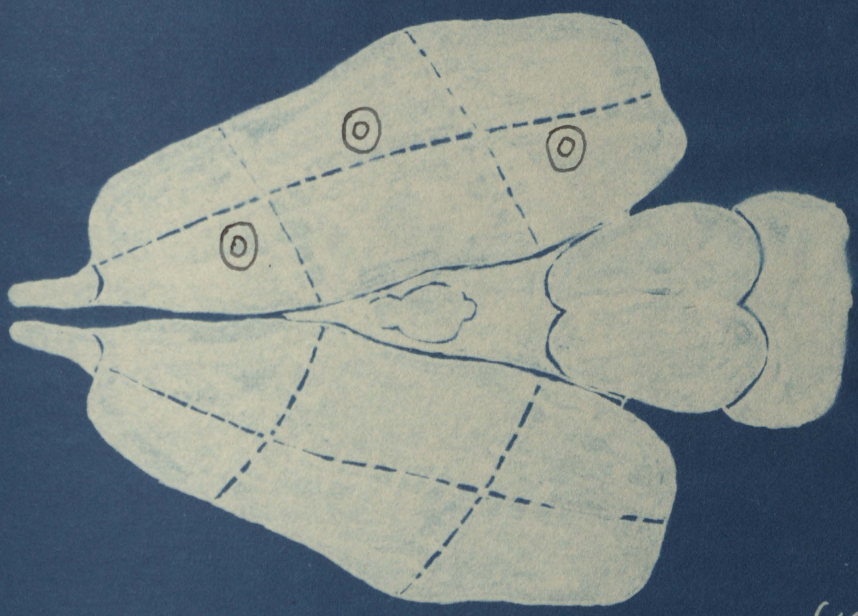

fig. 2

PLATE XIX

It will be noted on examination of the plate and the table only one region shows any activity. This is the right middle lateral forebrain, which supposedly has an olfactory and somatic function. The average magnitude for all the records under this condition is .14.

(b). Animal Passive When Body Was Hit or Pinched, or Eye Touched. In this case the animal's body was hit or pinched or its eye touched with a pencil. The animal remained passive. The data are in Table XXVII and Plate XIX, figure 2.

Table XXVII

Brain Position	Record Type	Average Magnitude
Rt. ant. med. fore.	1	0
Rt. mid. lat. fore.	1	0
Rt. post. fore.	1	0
	3 Records	Average 0

It will be noted that all of the positions studied were entirely negative. The average is 0 for this situation.

(c). Animal Writhed Very Slightly When Body Stroked. In this case the pencil rubber was lightly stroked over the animal's body, in response to which the animal writhed slightly. The data are given in Table XXVIII and in Plate XX, figure 1.

Table XXVIII.

Brain Position	Record Type	Average Magnitude
Rt. ant. med. fore.	1	0
Lft. ant. fore.	1, 1	0
	3 Records	Average 0

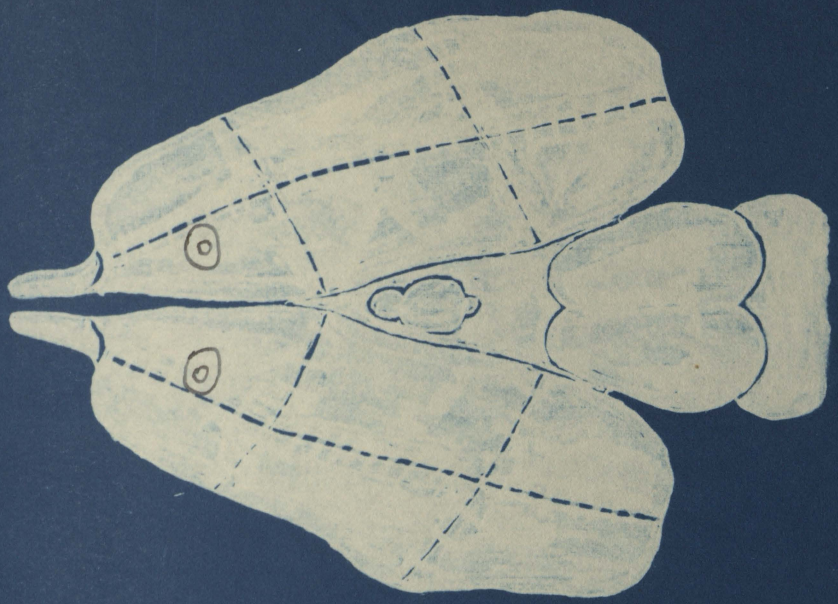

fig. 1

fig. 2

PLATE XX

It will be noted that the regions studied are all negative. These include, for the most part, the olfactory areas in the anterior forebrain.

(d). Animal Wincing or Writhing When Tapped Head or Pinched Body. In this case the animal writhed or winced fairly vigorously when its head was tapped with the pencil or its body was pinched. See Table XXIX and Plate XX, figure 2. A peak of activity occurs in the right middle lateral fore-

Table XXIX.

Brain Position	Record Type		Average Magnitude
Rt. ant. med. fore.	6		2.0
Rt. mid. lat. fore.	5,8,4		3.3
Rt. post. fore.	6		2.0
Lft. ant. fore.	7,6,6,4		2.5
Lft. mid. med. fore.	6		2.0
Lft. post. fore.	8,13		1.5
	12 records	Average	2.21

brain, which is ascribed an olfactory and somatic function. There are several regions of medium activity, which include the motor, visual and the remainder of the olfactory region. The gross average magnitude, in this case, is 2.21 as compared with 0 when the animal was passive under tactual stimulation and .14 when the animal was passive in the room light.

(e). Animal Struggled Vigorously When Punched Inside Mouth. In this case the animal struggled vigorously. The data is shown in Table XXX and Plate XXI, figure 1. All of the regions studied exhibit maximum amplitude. These include the olfactory, motor and visual areas. The gradient is similar to that with wincing and writhing, except that the level

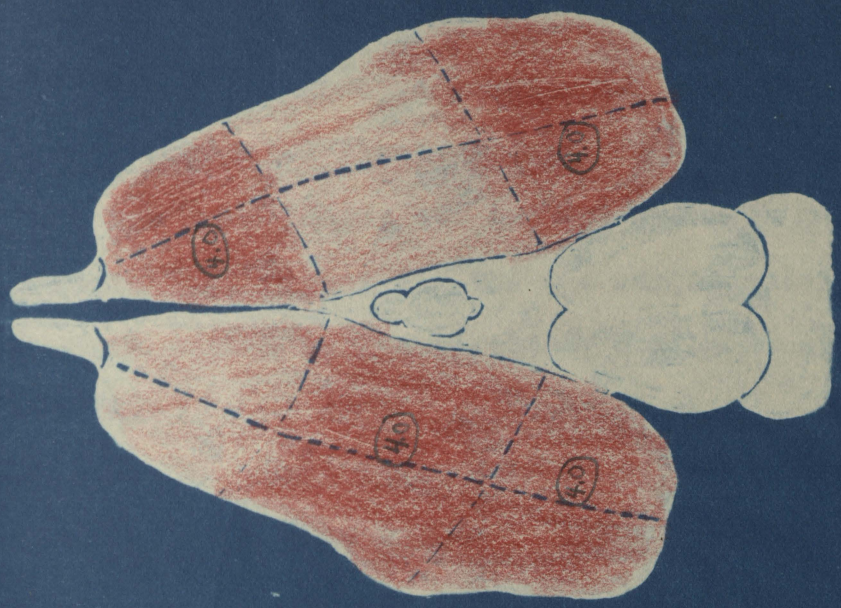

fig. 1

fig. 2

PLATE XXI

is now at a maximum. The gross average in this case is 4.0 as compared with 2.21 under mere wincing and writhing.

(f). Animal Struggled Spontaneously. The data under this situation are very incomplete but are shown in Table XXXI and in Plate XXI, figure 2. The one region studied is maximum. This occurs in the olfactory region in the anterior forebrain.

Table XXXI

Brain Position	Record Type	Average Magnitude
Rt. ant. med. fore.	10, 4	4.0
	Two Records	Average 4.0

(g). Animal Passive With Quincke Tube Stimulation. In this case the 1024 d.v. quincke tube was blown, while the animal remained passive. See Table XXXII, and Plate XXII, figure

Table XXXII.

Brain Position	Record Type	Average Magnitude
Rt. ant. med. fore.	1	0
Rt. mid. lat. fore.	1	0
Lft. ant. fore.	8	2.0
	3 Records	Average .66

1. Only one of the regions showed any activity and this was medium. It was the left olfactory region. The average magnitude of these records was .66.

(3). Conclusions on the Reptile.- The data presented in this section, on the snake, can be summarized under six heads: light stimulation; tactual stimulation with the animal passive;

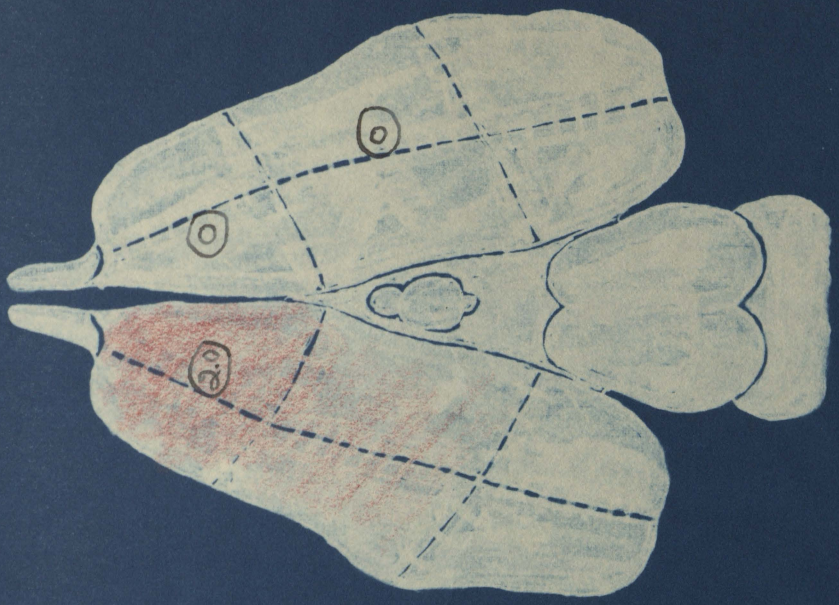

fig. 1

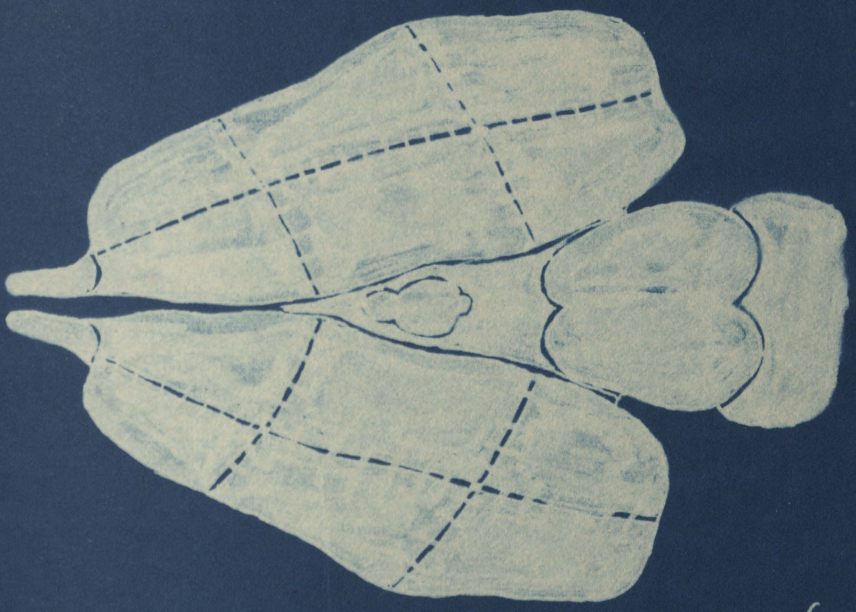

fig. 2

PLATE XXII

tactual stimulation with the animal active; pain stimulation with the animal reacting; spontaneous activity of the animal; and auditory stimulation.

(a). Light Stimulation. There is only one situation under this heading, (a), in which the animal was passive to room light stimulation. The olfactory-and-somatic region is the only one which shows activity. The average magnitude is .14.

(b). Animal Passive With Tactual Stimulation. The one situation in this group, (b), was with the animal passive when its body was hit or pinched or its eye touched with the pencil. In this case all of the records are negative. The average magnitude is 0 as compared with .14 under room light stimulation.

(c). Animal Active Under Tactual Stimulation. The first behavior situation under this group, (c), was with the animal writhing slightly when its body was struck with the pencil. In this case all the records are negative. In the next situation, (d) the animal winced and writhed when its head was tapped or its body pinched. The peak of activity, in this case, occurred in the olfactory and somatic region, while the remainder of the olfactory, the motor and visual regions were moderately active. The gross average magnitude, in this case, was 2.21. The average of the two situations in this group gave 1.10 as compared with 0 under tactual stimulation with the animal passive, and .14 when the animal was passive in the room light.

(d). Animal Active Under Pain Stimulation. In the one situation which fell in this group, (e), the animal struggled

vigorously when the inside of its mouth was punched with the pencil point. All of the regions studied were maximum in amplitude, which included the olfactory, motor and visual areas. The gradient is similar to that under active to tactual stimulation, but the level has been raised to a maximum and the different regions have become homogeneous. The average magnitude, under this condition, is 4.0 as compared with 1.10 when the animal was active to tactual stimulation, 0 when the animal was passive under tactual stimulation, and .14 when the animal was passive in the room light.

(e). Spontaneous Activity of the Animal. In this situation, (f), the animal was spontaneously struggling. The one region studied under this condition was maximum. This was the anterior forebrain which is ascribed an olfactory function. The average magnitude is 4.0 as compared with 4.0 when the animal was active under pain stimulation, and 1.10 when the animal was active under tactual stimulation.

(f). Auditory Stimulation. In this situation, (g), the animal was stimulated with a 1024 d.v. quincke tube, but remained passive. One area was moderately active, the left anterior olfactory region. The average magnitude in this case was .66 as compared with .14 under room light stimulation, 0 with the animal passive to tactual stimulation, 1.10 with the animal adtive under tactual stimulation, and 4.0 with the animal active under pain stimulation.

V. THE BIRD.

(1). Description of Experiments and Records - Eight experiments were performed on the pigeon, in which 357 records were secured. Plate XXIII shows the avian brain with the arbitrary regions used to locate the electrodes. The circles with letters, scattered over the map, mark all the electrode positions used in the experiments.

Pigeon P April 28, 1933, 8:00 p.m.

Description of Records:

Record 1. The animal was passive except for blinking. Electrode: lft. upper ant. med. forebrain. The record is negative. Type 1 (0).

Record 2. Animal passive. Electrode: lft. upper ant. med. forebrain. The record is negative. Type 1 (0).

Record 3. Closed circuit. Record is negative. Type 1 (0).

Record 4. Punched right eye with pencil. Winked. Electrode: lft. upper ant. med. forebrain. The first fourth of the record is quiet. Then there starts a series which begins fairly abruptly and goes to 17 mm. in amplitude and then gradually tapers off. The last half of the record is fairly quiet. Type 3 (4).

Record 5. Punched right eye with pencil. Animal jumped and winked. Electrode: lft. upper ant. med. forebrain. There is an extended series which starts just after the record started, and rises abruptly to 25 mm. amplitude. This series lasts for 60 mm. gradually subsiding, followed by a short series which reaches 15 mm. At the end of the record (20 mm. from end) there is another short series which reached 10 mm. in amplitude. Type 3 (4).

Record 6. Moved animal's head. Animal passive, but still blinking. Electrode: lft. upper anterior med. forebrain. The first part of the record shows scattered throws of 5 mm. amplitude. These become more numerous toward the middle of the record, then subside until toward the end, when there is a short series of 8 mm. amplitude. Type 8 (2).

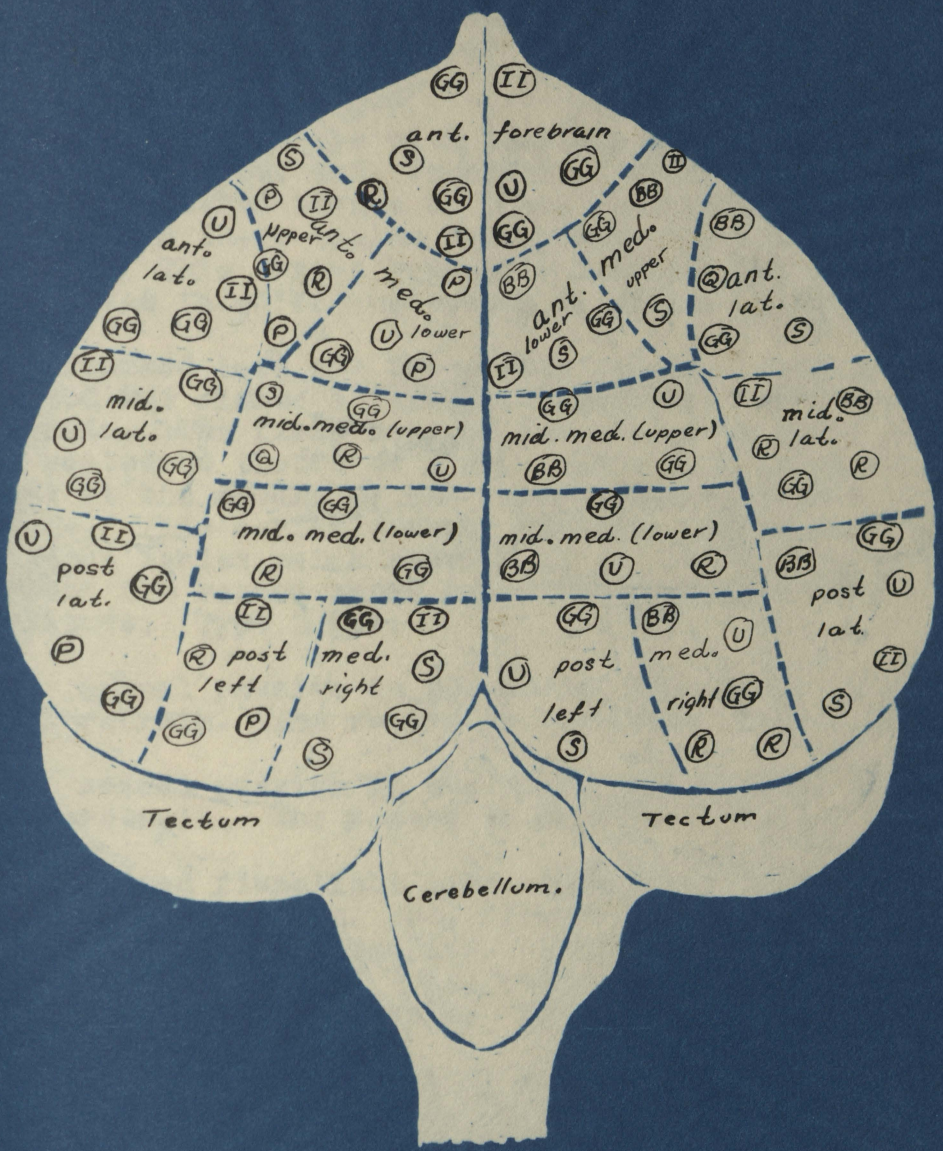
ant.
forebrain
ant.
lat.
upper
ant.
med.
lower
ant.
lower
med.
upper
ant.
lat.
mid.
lat.
mid. med. (upper)
mid. med. (upper)
mid.
lat.
mid. med. (lower)
mid. med. (lower)
post
lat.
post
left
med.
right
post
left
med.
right
post
lat.
Tectum
Tectum
Cerebellum.

PLATE XXIII

Record 7. Pulled animal's tail. Mostly passive, but slight wincing. Eye blinking. Electrode: lft. upper ant. med. forebrain. The record is quiet except for a short series just before the end. This series reaches 12 mm. in amplitude. Type 8 (2).

Record 8. Punched left eye with pencil. Animal blinked. Electrode: lft. upper ant. med. forebrain. The first half of the record shows scattered throws of 5 mm. amplitude. At the center of the record there begins fairly abruptly a series which reaches 15 mm. This series gradually subsides but continues for 70 mm. The last third of the record is quiet. Type 3 (4).

Record 9. Punched left eye twice with pencil. Animal's eye partly closed but winced slightly. Electrode: lft. upper ant. med. forebrain. The first half of the record is quiet except for a few scattered throws of 5 mm. There is a short series (the first) at the middle of the record, which reaches 10 mm. in amplitude. This series quickly subsides but is followed by a second short series which reaches 12 mm. in amplitude. The last third of the record shows again the scattered throws of 5 mm. amplitude. Type 3 (4).

Record 10. Animal passive in the dark. Electrode: lft. upper ant. med. forebrain. The record is negative. Type 1 (0).

Record 11. Animal passive in the dark. Electrode: lft. upper ant. med. forebrain. The record is negative. Type 1 (0).

Record 12. Shined flashlight into right eye. Animal passive. Electrode: lft. upper ant. med. forebrain. The first three fourths of the record is negative. After this there is a short series with an amplitude of 7 mm. which continues in scattered fashion to the end of the record. Type 8 (2).

Record 13. Shined flashlight into right eye. Animal passive. Electrode: lft. upper ant. med. forebrain. The record shows scattered throws of 5 and 6 mm. throughout. Type 13. (1).

Record 14. Animal passive, but blinking. Electrode: lft. upper ant. med. forebrain. The record is negative. Type 1 (0).

Record 15. Animal passive, but blinking. Electrode: lft.post. lft. med. forebrain. The record shows scattered throws of 5 mm. amplitude. There is a very short series of these toward the first of the record. Type 13 (1).

Record 16. Punched animal's right eye with pencil. Blinked. Electrode: lft. post. lft. med. forebrain. The first fourth of the record is quiet. At this point there begins rather abruptly a long series which shows a height of 20 mm. This series gradually subsides and is quiet until just before the end when there is a short series of 13 mm. amplitude. Type 10 (4).

Record 17. Lost.

Record 18. Punched right eye with pencil. Animal blinked and winced slightly. Electrode: lft. upper ant. med. forebrain. The first third of the record is quiet at the end of which there begins abruptly a long series which reaches an amplitude of 25 mm. The throws are irregular in height, however. The series gradually subsides so that the last third of the record is quiet. Type 11 (4).

Record 19. Sounded 325 d.v. fork into right ear. Animal's eyes widened; and turned head slightly. Electrode: lft. upper ant. med. forebrain. Shortly after the beginning of the record there occurred a series which reaches 13 mm. in amplitude. This series gradually subsides and scatters out, so that the last half of the record is quiet. Type 3 (4).

Record 20. Sounded 325 d.v. fork into animal's right ear. Animal's eyes widened. Electrode: lft. post. lft. med. forebrain. The record shows scattered throws of 5 mm. throughout. 50 mm. from the end of the record there occurs a short series which reaches 10 mm. in amplitude. Type 8 (2).

Record 21. Sounded 325 d.v. fork into right ear. Animal passive. Electrode: lft. post. lft. med. forebrain. Shortly after the beginning of the record there occurs a series which reaches 8 mm. in amplitude. This gradually subsides so that the last half of the record is quiet. Type 8 (2).

Record 22. Sounded 325 fork into right ear. Animal blinked and turned head slightly. Electrode: lft. post. lft. med. forebrain. Shortly after the beginning of the record there occurs a series of fast, irregular throws which go as high as 11 mm. The remainder of the record is fairly quiet. Type 9 (2).

Record 23. Sounded 325 d.v. fork in right ear of animal. Animal passive. Electrode: lft. upper ant. med. forebrain. The record shows scattered throws of 5 mm. throughout, with the beginning of a series toward the first of the record. Type 13 (1).

Record 24. Animal passive in the dark. Blinked once about the time of record. Electrode: lft. upper ant. med. forebrain. The record is negative. Type 1 (0).

Record 25. Animal passive in the dark. Blinked once. Electrode: lft. post. lft. med. forebrain. The record shows scattered throws of 5 mm. throughout. About 50 mm. from the end of the record there is a short series, one throw of which is 9 mm. Type 13 (1).

Record 26. Shined flashlight into right eye of animal. Widened eye. Electrode: lft. post. lft. med. forebrain. The first third of the record is quiet. At the end of this section there

occurs a short series, which reaches 9 mm. in amplitude. At the beginning of the last third of the record there occurs a second series which reaches 10 mm. in amplitude. Type 8 (2).

Record 27. Shined flashlight into right eye. Eye widened. Electrode: lft. upper ant. med. forebrain. The first fourth of the record is quiet. At the beginning of the next fourth there commences abruptly a series of 12 mm. amplitude. This gradually subsides and scatters out, but the rest of the record shows scattered throws. Type 7 (2).

Record 28. Punched back with pencil. Animal wriggled slightly. Electrode: lft. upper ant. med. forebrain. The first two thirds of the record is quiet. At the beginning of the last third there is a short series which reached 13 mm. At the very end of the record there are sdattered throws of 5 mm. Type 6 (2).

Record 29. Waved arm suddenly at animal. Animal jumped slightly. Electrode: lft. post. lft. med. forebrain. The first two thirds of the record is passive. At the beginning of the last third there occurs a short series which reaches 13 mm. in amplitude. After this gradually subsided there were scattered 5 mm. throws for the rest of the record. Type 6 (2).

Record 30. Punched back with pencil. Animal passive. Electrode: lft. post. lft. med. forebrain. There is a short series near the first of the record of 9 mm. amplitude. The remainder of the record is quiet. Type 6 (2).

Record 31. Animal passive. Electrode: lft. lower ant. med. forebrain. The record is negative. Type 1 (0).

Record 32. Animal passive. Electrode: lft. post. lat. forebrain. The record is negative. Type 1 (0).

Record 33. Punched right eye of animal with pencil. Animal blinked and winced slightly. Electrode: lft. post. lat. forebrain. The first fifth of the record is quiet. At the beginning of the next section there is a large series which commences abruptly and reaches 20 mm. in amplitude. This scatters and subsides and is followed shortly by a smaller series of 10 mm. throws. A series of low (7, 8, 9 mm.) amplitude commenced in the last fifth of the record, lasting for 50 mm. Type 4 (4).

Record 34. Punched right eye of animal with pencil. Animal blinked and winced slightly. Electrode: lft. lower ant. med. forebrain. The record begins quietly, but begins to show monophasic waves of 7 mm. amplitude. At the beginning of the second fifth of the record there begins a large series that reaches 20 mm. in amplitude. This gradually subsides. At the beginning of the last fifth of the record there is a short series of 9 mm. amplitude. At the very end of the record there is another series of 9 mm. amplitude. Type 3 (4).

Record 35. Waved arm suddenly in front of animal's right eye. Animal jumped. Electrode: lft. lower ant. med. forebrain. The first third of the record is quiet. At this point there is a short series which rises abruptly to 17 mm. This gradually subsides. At the beginning of the last third of the record there is another series which reaches 10 mm. in amplitude. 25 mm. from the end of the record there is a series of 12 mm. throws. Type 4 (4).

Record 36. Punched animal's back with pencil. Animal winced slightly. Electrode: lft. post. lat. forebrain. The first half of the record shows scattered throws of 5 mm. There is a short series of 8 mm. throws at the end of the section. 70 mm. from the end of the record there is a series which shows throws of 11 mm. in amplitude. Type 8 (2).

Record 37. Animal passive in the dark. Electrode: lft. post. lat. forebrain. The record is negative. Type 1 (0).

Record 38. Animal passive in the dark. Blinked about the time of the record. Electrode: lft. lower ant. med. forebrain. The record is negative. Type 1 (0).

Record 39. Shined flashlight into animal's right eye. Animal passive. Electrode: lft. lower ant. med. forebrain. The record shows scattered throws of 5 mm. throughout. The last fifth of the record shows throws of 7 and 8 mm. Type 13 (1).

Record 40. Shined flashlight into right eye of animal. Animal passive. Electrode: lft. post. lat. forebrain. The record shows scattered throws of 5 and 6 mm. amplitude. Type 13 (1).

Record 41. Sounded 325 fork into right ear of animal. Animal passive. Electrode: lft. posterior lat. forebrain. The record shows some sort of activity throughout. The record begins with a series which reaches 12 mm. in amplitude. This gradually scatters and subsides, showing 5 and 6 mm. throws until the beginning of the last third of the record when there appears another series of 10 mm. amplitude. Type 7 (2).

Record 42. Sounded 325 d.v. fork into the right ear of animal. Animal passive. Electrode: lft. lower ant. med. forebrain. The beginning of the record is quiet but there is a short series just after the record started of 9 mm. amplitude. At the middle of the record there is another series, somewhat longer, of 10 mm. amplitude. The last half of the record is quiet. Type 8 (2).

Record 43. Animal wriggled slightly. Electrode: lft. lower ant. med. forebrain. The first two thirds of the record is quiet. At the beginning of the last third there is a short series which reaches 9 mm. Type 8 (2).

Record 44. Stroked animal's feathers. Winced and wriggled slightly. Electrode: lft. post. lat. forebrain. The re-

cord shows scattered activity throughout. About 50 mm. after the beginning of the record there is a series of 10 mm. amplitude. This gradually subsides and the rest of the record shows scattered throws of 5 and 6 mm. amplitude. Type 9 (2).

Record 45. Blew at animal. Animal winked and turned head slightly. Electrode: lft. post. lat. forebrain. Just after the beginning of the record there occurs a large series which reaches 23 mm. amplitude. This series is abrupt in onset, but tapers off rather gradually into monophasic waves of 5 mm. At the center of the record there is a short series of 10 mm. In the last third of the record there is a short series of 12 mm. Type 4 (4).

Record 46. Blew at animal. Animal winked and shook head. Electrode: lft. post. lat. forebrain. Shortly after the beginning of the record there starts abruptly a series of 17 mm. amplitude. Shortly after this there is a series of 10 mm. Just after the center of the record there is another series of 9 mm. amplitude. Type 4 (4).

Record 47. Blew at animal's head. Animal turned head down. Electrode: lft. lower ant. med. forebrain. Shortly after the beginning of the record there is an abrupt series of 16 mm. which ends rather quickly after 25 mm. The last 50 mm. of the record shows a series of 10 mm. amplitude. Type 4 (4).

Pigeon Q April 29, 1933, 9:00 p.m.

Description of Records:

Record 1. The animal was passive. Electrode: rt. ant. lat. forebrain. The first part of the record is passive but there are scattered throws of 5 mm. amplitude toward the end. Type 13 (1).

Record 2. The animal was passive. Electrode: Lft. upper mid. med. forebrain. The record shows scattered throws of 5 mm. amplitude. Type 13 (1).

Record 3. Closed circuit. The record is negative. Type 1 (0).

Record 4. Punched right eye with pencil. Animal jumped, blinked, struggled and raised wings. Electrode off at end of record. Electrode: right ant. lat. forebrain. The record started with a series of throws of 20 mm. amplitude. They become as high as 40 mm. There were, then, intersperced slow throws of 40 mm. amplitude which indicate movement of the electrode. However, fast throws of 40 mm. amplitude are maintained throughout the first half of the record. This is followed by a series which shows an amplitude of 25 mm. The last fourth of the record shows again slipping of the electrode. Type 11 (4).

Record 5. Punched animal's right eye with pencil. Animal jumped, blinked, struggled and raised wings. Electrode: lft. upper mid. med. forebrain. The first 40 mm. of the record is quiet. At this point there begins a series which is 15 mm. in amplitude. Then the record suddenly mounts to 50 mm. in amplitude and is followed by a slow electrode throw. The record then lowers to 10 mm. amplitude and gradually subsides until the last fourth of the record, when the activity of 15 mm. amplitude again continues to the end of the record. Type 4 (4).

Record 6. Punched animal's back with pencil. Bird winced. Electrode: lft. upper mid. med. forebrain. The beginning of the record is quiet, but at the end of the first third there is a short series, the throws of which range up to 9 mm. in height. Type 8 (2).

Record 7. Punched animal's back with pencil. Animal winced slightly. Electrode: rt. ant. lat. forebrain. The record shows scattered throws of 5 mm. amplitude throughout the record. There is a short series at the first of the record. Type 13 (1).

Record 8. is a blank.

Record 9. Shined flashlight in animal's eye after record started. Electrode: rt. ant. lat. forebrain. Animal passive. The record shows scattered throws of 5 mm. amplitude throughout the record. Type 13 (1).

Record 10. Shined flashlight into right eye after record started. Animal passive. Electrode: left upper mid. med. forebrain. The first two thirds of the record are negative. At the beginning of the last third, however, there is a short series which ranges up to 9 mm. in amplitude. The last portion of the record is quiet. Type 8 (2).

Record 11. Sounded 325 d.v. tuning fork into right ear of animal after the record had started. The animal wriggled at the end of the record. Electrode: lft. upper mid. med. forebrain. The first two thirds of the record are quiet. The last third shows a short series with throws of 9 mm. amplitude. This series extends irregularly for 50 mm. Type 8 (2).

Record 12. Sounded 325 d.v. tuning fork into right ear of animal after the record started. The animal was passive. Electrode: rt. ant. lat. forebrain. The first fifth of the record is negative. At the end of this section there occurs a series with throws of 9 mm. amplitude. The remainder of the record is fairly quiet but shows a few scattered throws of 5 mm. amplitude. Type 8 (2).

Record 13. Sounded quincke tube into right ear of animal after the record started. Animal winced slightly. Electrode: rt. ant. lat. forebrain. The first half of the record is quiet,

except for a few scattered throws of 5 mm. amplitude. There is a fairly extended series at the end of the first half which shows throws of 12 mm. amplitude. The end of the record is quiet. Type 3 (4).

Pigeon R May 2, 1933, 9 p.m.

Description of Records:

Record 1. Closed circuit. Record is negative. Type 1 (0).

Record 2. Animal fairly quiet. Electrode: rt. lower mid. med. forebrain. The record shows throws, scattered throughout, of from 5 to 7 mm. amplitude. Type 13 (1).

Record 3. Animal passive. Electrode: lft. lower mid. med. forebrain. The record is negative. Type 1 (0).

Record 4. Punched animal's right eye with pencil. Animal winked and winced slightly. Electrode: lft. lower mid. med. forebrain. The first third of the record shows scattered throws of 5 mm. amplitude. Then there begins rather abruptly a series of throws of 12 mm. amplitude. This series lasts for 70 mm. and the remainder of the record shows the scattered throws that appeared in the first part of the record. Type 7 (2) plus.

Record 5. Punched animal's right eye with pencil. Animal blinked and winced slightly. Electrode: rt. lower mid. med. forebrain. The first part of the record is quiet, but there soon begins, abruptly, a series which goes up to 16 mm. amplitude. This gradually subsides and the rest of the record shows scattered throws of 5 mm. amplitude. Type 5 (4).

Record 6. Blew at animal. Animal winked. Electrode: rt. lower mid. med. forebrain. The record commences with a series of throws which go as high as 12 mm. amplitude. This series lasts for 60 mm. and then gradually tapers off and scatters so that the remainder of the record shows scattered 5 mm. throws. Type 7 (2) plus.

Record 7. Blew at animal's head. Animal winked. Electrode: lft. lower mid. med. forebrain. The first of the record is quiet but there soon begins a series which attains 12 mm. in amplitude. The end of this series is a single throw of 12 mm. The last half of the record is quiet. Type 7 (2) plus.

Record 8. Moving animal's head. Animal passive. Electrode: lft. lower mid. med. forebrain. The record shows, throughout, scattered throws of 5, 6, and 7 mm. amplitude. Type 13 (1).

Record 9. Moving animal's head. Animal passive. Electrode: rt. lower mid. med. forebrain. The record shows scattered throws of 5 and 6 mm., throughout. Type 13 (1).

Record 10. Pulled animal's tail. Animal winced slightly. Electrode: rt. lower mid. med. forebrain. The record begins with a series which reaches 10 mm. in amplitude. This series is mainly monophasic waves. The remainder of the record is scattered, with 5 mm. throws. Type 7 (2) plus.

Record 11. Animal spontaneously moved head. Electrode: rt. lower mid. med. forebrain. The record shows small 5, 6, and 7 mm. amplitude activity throughout. There is a definite series at the end of the record. Type 9 (2).

Record 12. Moved head slightly, spontaneously. Electrode: lft. lower mid. med. forebrain. The record shows small activity throughout of 5, 6 and 7 mm. throws. These form two short series in the first half of the record. Type 8 (2).

Record 13. Animal wriggling spontaneously. Electrode: lft. lower mid. med. forebrain. The first half of the record is quiet. Shortly after the beginning of the second half there is a series which reaches 9 mm. in amplitude. The last fourth of the record is quiet. Type 8 (2).

Record 14. High siren sounded into right ear of animal. Animal passive. Electrode: lft. lower mid. med. forebrain. The first two thirds of the record shows scattered throws of 5 and 6 mm. amplitude. At the beginning of the last third of the record there is a series which reaches 9 mm. in amplitude. This series lasts for 50 mm. Type 8 (2).

Record 15. Sounded siren into right ear of animal. Animal passive. Electrode: rt. lower mid. med. forebrain. The record shows scattered throws of 5 and 6 mm., throughout. Type 13 (1).

Record 16. Animal quiet. Electrode: rt. mid. lat. forebrain. The record shows scattered throws of 5 mm. Type 13 (1).

Record 17. Animal passive. Electrode: lft. upper ant. med. forebrain. The record is negative. Type 1 (0).

Record 18. Punched animal's right eye with pencil. Animal winked. Electrode: lft. upper ant. med. forebrain. The first part of the record shows small 5 mm. throws. There soon begins an extended series which reaches 16 mm. in amplitude. This series gradually subsides and scatters. At the beginning of the last third there is a short series of 6 mm. throws. Type 5 (4).

Record 19. Punched right eye with pencil. Animal blinked. Electrode: rt. mid. lat. forebrain. The first part of the record is quiet, but a series of 10 mm. throws soon commences and last for 50 mm. The rest of the record is quiet. Type 9 (2). plus.

Record 20. Punched neck. Animal passive. Electrode: rt. mid. lat. forebrain. The record is negative. Type 1 (0).

Record 21. Pushed neck. Animal moved head. Electrode: rt. mid. lat. forebrain. The first third of the record is quiet. At the beginning of the second third there is a fairly long series of 12 mm. amplitude. The whole last half of the record shows small 5 mm. activity. Type 9 (2).

Record 22. Animal passive. Electrode: rt. mid. lat. forebrain. The record shows scattered throws of 5 mm. amplitude throughout. Type 13 (1).

Record 23. Animal passive. Electrode: lft. upper mid. med. forebrain. The record is negative. Type 1 (0).

Record 24. Punched animal's right eye with pencil. Animal blinked. Electrode: lft. upper mid. med. forebrain. The first 40 mm. of the record is quiet. Then there begins abruptly a series which reaches 17 mm. in amplitude. There are two types of throws in this series. The first are very fast and diphasic, the last are larger, largely monophasic, and quiet slow. The remainder of the record is quiet. Type 4 (4).

Record 25. Punched right eye with pencil. Animal blinked. Electrode: rt. mid. lat. forebrain. The first 60 mm. of the record shows scattered throws of 5 mm. amplitude. Then there begins a series which reaches 12 mm. amplitude. This series gradually subsides into scattered throws of 5 mm. amplitude. The last fifth of the record contains another series of 12 mm. amplitude, which lasts to the end of the record. Type 9 (2) plus.

Record 26. Animal moved head slightly. Electrode: rt. mid. lat. forebrain. The record shows scattered throws throughout the first two thirds of 5 and 6 mm. In the last third there is a series of 9 mm. amplitude. Type 8 (2).

Record 27. Punched neck with pencil. Animal moved head slightly. Electrode: lft. upper mid. med. forebrain. The first 40 mm. of the record are quiet. At this point there occurs a short series of 10 mm. amplitude. The remainder of the record shows scattered throws of 5 mm. Type 8 (2).

Record 28. Punched bill with pencil. Animal swallowed three times. Electrode: lft. upper mid. med. forebrain. The record shows very peculiar series. There are three of these spaced regularly throughout the record at 80 mm. from the first of one to the beginning of the next. The series starts abruptly at 17 mm. amplitude with very fast and closely spaced throws. Then the frequency becomes very low and at the same time the amplitude decreases gradually until the series dies out, just before the next one starts. The first and third sets are nearly identical. The center one tapers off a little more rapidly then the other two. Type 11 (4).

Record 29. Punched bill three times. Animal moved head slightly. Electrode: rt. mid. lat. forebrain. The spacing of the series is much the same in this record as in the last one, but all of the throws are of fast frequency. There is a series, just after the record started, abruptly rising to 17 mm. amplitude. This tapers off gradually to 5 mm. throws which last to the beginning of the next series at the center of the record. This series has an amplitude of 20 mm. which is maintained for 25 mm. It decreases rather abruptly to an amplitude of 10 mm. The last series occurred at the beginning of the last third of the record and reaches 20 mm., then subsides and increases again. Type 11 (4).

Record 30. Sounded quincke tube into right ear of animal. Animal passive. Electrode: rt. mid. lat. forebrain. The record shows a series, toward the first, of 6 mm. amplitude. These same throws are scattered throughout the record. Type 13 (1).

Record 31. Animal moved head violently, spontaneously. Electrode: rt. mid. lat. forebrain. The record shows small scattered activity at the outset which gradually increases in size to form a series, which reaches 23 mm. in amplitude. This series subsides rather abruptly but is followed closely by another which abruptly reaches 16 mm. amplitude. The latter half of the record shows scattered throws of 5 mm. Type 11 (4).

Record 32. Animal moved head spontaneously. Electrode: rt. mid. lat. forebrain. The record shows activity at the outset, which gradually increases to form a series reaching 17 mm. amplitude. This series extends for 130 mm.; shows great irregularity, and very fast throws. The beginning of the second half of the record shows another series of 9 mm. amplitude, which extends for 100 mm. and which is also very irregular. This series ends with a single throw of 12 mm. The very end of the record is quiet. Type 11 (4).

Record 33. Animal moved head spontaneously. Electrode: rt. mid. lat. forebrain. In the first third of the record there is a single throw of 12 mm. Following this there is a small series of 9 mm. throws. At the center of the record there is a series of 17 mm. amplitude which tapers off into throws of 7, 8, 9 mm. to the end of the record. Type 4 (4).

Record 34. Quincke Tube sounded into right ear of animal. Animal passive. Electrode: lft. upper mid. med. forebrain. The record is negative. Type 1 (0).

Record 35. Animal struggled just before record. Electrode: lft. upper mid. med. forebrain. There are scattered throws of 7 mm. amplitude in the first half of the record. Type 13 (1).

Record 36. Animal passive. Electrode: rt. post. rt. med. forebrain. The record is negative. Type 1 (0).

Record 37. Animal passive. Electrode: lft. ant. forebrain. Type 1 (0).

Record 38. Punched right eye with pencil. Animal blinked. Electrode: lft. ant. forebrain. The beginning of the record is quiet. At the end of the first fourth there is a series which reaches 8 mm. amplitude. Type 8 (2).

Record 39. Punched right eye with pencil. Animal blinked. Electrode: rt. post. rt. med. forebrain. The first fourth of the record is quiet. At the end of this section there occurs a long series which starts abruptly and goes up to 12 mm. and then tapers off very gradually. In the last third of the record there is a smaller series of 8 mm. amplitude. Type 9 (2) plus.

Record 40. Sounded quincke tube into right ear of animal. Animal opened right eye. Electrode: rt. post. rt. med. forebrain. The first fourth of the record is quiet. At the beginning of the next section there is a series of 10 mm. throws. The remainder of the record is quiet. Type 8 (2).

Record 41. Sounded quincke tube into right ear of animal. Opened eye and turned head slightly. Electrode: lft. ant. forebrain. The record shows only a single throw of 6 mm. Type 1 (0).

Record 42. Animal wriggled and struggled slightly. Electrode: lft. ant. forebrain. The record shows scattered throws of 5 and 6 mm. amplitude. Type 13 (1).

Record 43. Rolled body. Animal passive. Electrode: rt. post. rt. med. forebrain. The record is negative. Type 1 (0).

Records 44 to 46 are blank.

Record 47. Animal passive. Electrode: rt. post. rt. med. forebrain. The record is negative. Type 1 (0).

Record 48. Animal swallowing. Electrode: lft. post. lft. med. forebrain. The record is negative. Type 1 (0).

Pigeon S May 6, 1933, 8:00 p.m.

Description of Records:

Record 1. Animal passive. Electrode: rt. lower ant. med. forebrain. The record is negative. Type 1 (0).

Record 2. Animal passive. Electrode: lft. upper ant. med. forebrain. The record shows scattered throws of 5 and 6 mm. amplitude. Type 13 (1).

Record 3. Closed circuit. Record is negative. Type 1 (0).

Record 4. Punched eye (right) with pencil. Animal blinked and jumped slightly. Electrode: rt. lower ant. med. forebrain. The beginning of the record is quiet, but there soon begins to appear 5 mm. throws. These increase in size into a long series which reaches an amplitude of 17 mm. This series has one slow throw and then tapers off into fairly fast throws. The last half of the record shows scattered throws of 5 mm. Type 3 (4).

Record 5. Punched right eye with pencil. Animal jumped and blinked. Electrode: lft. upper ant. med. forebrain. The record starts quiet, but there soon commences a series which reaches 15 mm. in amplitude. This series extends for 60 mm. The remainder of the record is quiet. Type 3 (4).

Record 6. Punched right eye with pencil. Animal blinked. Electrode: rt. lower ant. med. forebrain. The first of the record is quiet for 50 mm. At this point a series starts abruptly at 10 mm. amplitude. This series continues for 70 mm. The remainder of the record is quiet. Type 9 (2) plus.

Record 7. Animal passive in the dark. Electrode: rt. lower ant. med. forebrain. The record is negative. Type 1 (0).

Record 8. Animal passive in the dark. Electrode: lft. upper ant. med. forebrain. The record is negative. Type 1 (0).

Record 9. Flashed light in right eye of animal. Animal passive. Electrode: lft. upper ant. med. forebrain. The record shows scattered throws of 5 and 6 mm. throughout. The number of these increase toward the end of the series. Type 13 (1).

Record 10. Shined flashlight into right eye of animal. Animal passive. Electrode: rt. lower ant. med. forebrain. The record shows scattered throws of 5 and 6 mm. throughout. These become very numerous toward the end of the record. Type 13 (1).

Record 11. Quincke tube was blown in right ear of animal. Animal jumped slightly. Electrode: rt. lower ant. med. forebrain. The record begins low, but increases to throws of 5 mm. and 6 mm. amplitude. There is a definite series of these in the first third of the record. The remainder of the record shows scattered activity of this small magnitude. Type 13 (1).

Record 12. Sounded quincke tube into right ear of animal. Animal wriggled. Electrode: lft. upper ant. med. forebrain. There is a short series of 10 mm. amplitude at the very outset of the record. This subsides into scattered activity of 5 mm. amplitude. In the center of the record there is another short series of 10 mm. amplitude. The remainder of the record shows the low amplitude activity. Type 8 (2).

Record 13. Punched animal's neck with pencil. Animal winced. Electrode: lft. upper ant. med. forebrain. There is a series just after the beginning of the record which reaches 12 mm. in amplitude. This gradually tapers off into scattered activity of 5, 6, 7 mm. amplitude. Just after the center of the record there is a short series of 10 mm. amplitude. Type 8 (2).

Record 14. Punched animal's neck. Animal winced slightly. Electrode: rt. lower ant. med. forebrain. The first half of the record is quiet. In the last third there is a series of 10 mm. throws which commences and ends, gradually. Type 8 (2).

Record 15. Animal passive. Electrode: rt. ant. lat. forebrain. The record is negative. Type 1 (0).

Record 16. Animal passive. Electrode: lft. ant. forebrain. The record is negative. Type 1 (0).

Record 17. Punched right eye with pencil. Animal winked. Electrode: lft. ant. forebrain. The first part of the record is negative. Then there begins abruptly a series of 10 mm. throws which subsides and then commences again. The last half of the record is quiet. Type 8 (2) plus.

Record 18. Punched right eye with pencil. Animal winked, shook head and knocked electrode off for short time. Electrode: rt. ant. lat. forebrain. The first fifth of the record shows scattered 6 mm. throws. A series commences at the beginning of the second series, which gradually reaches a maximum of 16 mm. amplitude. This series is broken by the slow throws which indicate movement of the electrode. Following these slow throws there is a very large and long series which reaches 50 mm. in amplitude. The throws are very fast and closely spaced. This series last until nearly the end of the record, when a single throw of 10 mm. ends the series abruptly. Type 11 (4).

Record 19. Sounded quincke tube into right ear of animal. Animal jumped near end of record. Electrode: rt. ant. lat. forebrain. The record shows activity throughout which consists of fast 10 to 20 mm. throws interspersed with slow 8 mm. throws. The characteristic arrangement is two fast throws then a slow one, so that the appearance if rhythmic. Type 9 (2). plus.

Record 20. Sounded quincke tube into right ear of animal. Animal winked. Electrode: lft. ant. forebrain. The record is negative. Type 1 (0).

Record 21. Animal passive in the dark. Electrode: lft. ant. forebrain. The record is negative. Type 1 (0).

Record 22. Animal passive in the dark. Electrode: rt. ant. lat. forebrain. The first part of the record is quiet. At the end of the record there is a short series which reaches 7 mm. amplitude. Type 13 (1).

Record 23. Shined flashlight into right eye of animal. Animal passive. Electrode: rt. ant. lat. forebrain. In the first fifth of the record there is a small series of 8 mm. amplitude. Then the record is fairly quiet except for scattered throws, until the last fifth, which shows a fairly extended series of 8 mm. amplitude. Type 8 (2(.

Record 24. Shined flashlight into right eye of animal. Animal passive. Electrode: lft. ant. forebrain. The record is negative. Type 1 (0).

Record 25. Punched animal's neck twice. Animal jumped. Electrode: lft. ant. forebrain. The record shows a series, at the very first, which reaches 9 mm. amplitude. Just after the center of the record there is another series which begins fairly abruptly, up to 10 mm., and then tapers off gradually. Type 8 (2).

Record 26. Punched animal's neck four times. Animal jumped and winced. Electrode: rt. ant. lat. forebrain. There is a series at the first of the record which reaches 16 mm. amplitude. This series tapers off into slow throws and is followed by another series of 10 mm. This subsides and in the center of the record there is another series of 10 mm. throws. In the last fourth of the record there occurs a fourth series of 10 mm. amplitude. Type 3 (4).

Record 27. Lost.

Record 28. Punched animal's back with pencil. Animal passive. Electrode: rt. ant. lat. forebrain. The record shows a short series of 10 mm. at first. Following this there are scattered throws of 5 mm. At the beginning of the last third there is a short series of 8 mm. throws. Another of this type appears at the end of the record. Type 8 (2) minus.

Record 29. Sounded 325 tuning fork into right ear of animal. Animal passive. Electrode rt. ant. lat. forebrain. The record shows scattered throws of 5 mm. amplitude throughout. Type 13 (1).

Record 30. Sounded 325 tuning fork into right ear of animal. Animal passive. Electrode: lft. ant. forebrain. The record is negative. Type 1 (0).

Record 31. Punched animal's bill twice with pencil. Animal jumped and winced slightly. Electrode: lft. ant. forebrain. The first fourth of the record is passive. Then there occurs a series which abruptly reaches 10 mm. amplitude and then gradually tapers off. In the last third of the record there occurs another series like the first, of 10 mm. amplitude. The end of the record is quiet. Type 8 (2) plus.

Record 32. Punched animal's bill three times. Animal jumped and struggled each time. Electrode: rt. ant. lat. forebrain. The record starts with a series which abruptly reaches 18 mm. amplitude and then gradually tapers off and scatters into 5

mm. throws. In the center of the record there is another series, which reaches 20 mm. amplitude. Toward the end of this series there is one slow throw. The series tapers off and scatters into 6 mm. throws. At the end of the record there is a third series, which reaches 40 mm. The electrode moved at the very end of the record. Type 11 (4).

Record 33. Animal passive. Electrode: rt. post. lft. med. forebrain. The record is negative. Type 1 (0).

Record 34. Animal passive. Electrode: lft. post. rt. med. forebrain. The record is negative. Type 1 (0).

Record 35. Punched animal's right eye with pencil. Animal blinked. Electrode: lft. post. rt. med. forebrain. The first part of the record shows a fairly extended series which reaches 12 mm. amplitude. The last two thirds of the record is quiet. Type 9 (2) plus.

Record 36. Punched right eye with pencil. Animal blinked. Electrode: rt. post. lft. med. forebrain. The record shows scattered throws of 5 and 6 mm. amplitude. Type 13 (1).

Record 37. Punched animal's bill twice. Animal jumped and raised head, so that electrode came off at end of record. Electrode: rt. post. lft. med. forebrain. The record begins with a series of 10 mm. amplitude. This gradually subsides into scattered activity of 5 mm. amplitude. In the center of the record there is a long series of 12 mm. amplitude, which ends with throws of 40 mm. Slow waves, characteristic of movement of the electrode then appear. The last half of the record shows several movements of the electrode interspersed with fast throws of 50 mm. which may be sighificant. Type 2 (4).

Record 38. Punched animal's bill with pencil three times. Animal jumped. Electrode: lft. post. rt. med. forebrain. The first third of the record shows a series with scattered throws of 8 mm. At the beginning of the second half of the record there is an abrupt series which reaches 18 mm. amplitude and then gradually tapers off. In the last fifth of the record there is a third series, which reaches 10 mm. amplitude. Type 2 (4).

Record 39. Sounded quincke tube into right ear of animal. Animal jumped before record taken. Electrode: lft. post. rt. med. forebrain. The record shows scattered throws, throughout, of 5 and 6 mm. amplitude. Type 13 (1).

Record 40. Sounded quincke tube into right ear of animal. Animal passive. Electrode: rt. post. lft. med. forebrain. The record shows scattered throws of 5 and 6 mm. amplitude throughout, with something of a series in the center. Type 13 (1).

Record 41. Sounded 325 tuning fork in right ear of animal. Animal blinked. Electrode: rt. post. lft. med. forebrain. The record shows scattered throws of 5 and 6 mm., throughout.

At the beginning of the last third there is a series of 8 mm. throws. Type 13 (1) plus.

Record 42. Sounded 325 tuning fork into right ear of animal. Animal passive. Electrode: lft. post. rt. med. forebrain. The record shows scattered throws of 5 and 6 mm. throughout. In the center of the record there is a short series of 8 mm. throws. Type 13 (1) plus.

Record 43. Animal spontaneously struggling, moving head, squirming body and snapping bill. Electrode: lft. post. rt. med. forebrain. The first four-fifths of the record show scattered throws of 6 and 7 mm. throughout. In the last fifth of the record there is a series which reaches 12 mm. amplitude. Type 8 (2).

Record 44. Animal spontaneously struggling, moving head, squirming body and snapping bill. Electrode: lft. post. rt. med. forebrain. The record begins with scattered activity of 5 mm. and gradually increases in amplitude, reaching a maximum of 15 mm. This series is very long, extending to the end of the record, with several peaks. In the center of the record there is a peak of 16 mm. At the beginning of the last third, a peak of 22 mm. and toward the very end of the record a peak of 26 mm. The record is irregular, but extended. Type 11 (4).

Record 45. Animal passive, but blinked during record. Electrode: rt. post. lat. forebrain. The record shows one short series of 7 mm. amplitude with scattered throws in the rest of the record. Type 13 (1).

Record 46. Animal passive. Electrode: lft. post. rt. med. forebrain. The record is negative. Type 1 (0).

Record 47. Punched right eye of animal with pencil. Animal blinked and moved head. Electrode: lft. post. rt. med. forebrain. The record shows a series at the very first which reaches 12 mm. amplitude. The rest of the record is quiet. Type 8 (2).

Record 48. Punched right eye with pencil. Animal blinked, jumped and raised head. Electrode: rt. post. lat. forebrain. The record commences with an extended series, which reaches 16 mm. amplitude. This series is uniformly high for 60 mm. and then tapers off rather abruptly to scattered 6 mm. throws. Type 10 (4) minus.

Record 49. Sounded quincke tube into animal's right ear. Animal blinked three times during record. Electrode: rt. post. lat forebrain. The first half of the record shows scattered throws of 5 and 6 mm. amplitude. At the beginning of the second half there is a short series of throws of 8 mm. amplitude. In the center of the last third there is a third series of 8 mm. amplitude throws. Type 13 (1).

Record 50. Sounded quincke tube into right ear of animal. Animal lowered head slightly. Electrode: lft. post. rt. med. forebrain. The record shows scattered throws of 6 and 7 mm. throughout. Just after the center of the record there is one single throw of 10 mm. Type 13 (1).

Record 51. Punched bill twice. Animal lowered head and neck and jumped. Electrode: lft. post. rt. med. forebrain. The record is quiet for 70 mm. There then commences a series which gradually reaches 10 mm. amplitude. This series gradually subsides into small activity until the beginning of the last third of the record, where there is a second series of 10 mm. amplitude. The last fifth of the record is quiet. Type 8 (2) plus.

Record 52. Punched animal's bill three times with pencil. Animal lowered head and neck and jumped. Electrode: rt. post. lat. forebrain. The record begins with an abrupt series which reaches 12 mm. and then tapers off gradually into small throws of 5 mm. After the center of the record there is an abrupt, short series which reaches 20 mm. amplitude. At the end of the record there is a third series which reaches 16 mm., but lasts longer than the others. Type 2 (4).

Record 53. Punched animal's neck twice with pencil. Animal jumped each time. Electrode: rt. post. lat. forebrain. The first fourth of the record shows activity of 5 mm. amplitude. At the beginning of the next section there is a series which commences abruptly at 16 mm. amplitude, and then gradually tapers off into small 6 and 7 mm. activity. At the beginning of the last fourth of the record there is a second series which reaches 12 mm. amplitude. Type 4 (4).

Record 54. Punched animal's neck three times with pencil. Animal jumped each time. Electrode: lft. post. rt. med. forebrain. The record commences with a short series of 9 mm. amplitude. At the center of the record a fairly long series occurs which reaches 10 mm. amplitude. 40 mm. from the end of the record a third series occurs which reaches 11 mm. amplitude. Type 8 (2).

Record 55. Hit animal's feet with pencil. Curled feet and wriggled. Electrode: lft. pos. rt. med. forebrain. The first half of the record shows scattered throws of 5 mm. amplitude. In the center of the record there is a series which reaches 9 mm. amplitude. The last third of the record is quiet. Type 8 (2).

Record 55a. Hit animal's feet with pencil. Curled feet and wriggled. Electrode: rt. post. lat. forebrain. The record shows a series, just after the record started, which reaches 10 mm. in amplitude. After this series there is scattered activity of 5 mm. Type 8 (2).

Record 56. Animal passive. Electrode: rt. upper ant. med. forebrain. The record is negative. Type 1 (0).

Record 57. Animal passive. Electrode: lft. upper mid. med. forebrain. The record shows activity of 7 mm. amplitude toward the first of the record. The latter part is quiet. Type 13 (1).

Record 58. Punched right eye of animal with pencil. Animal blinked and jumped. Electrode: lft. upper mid. med. forebrain. The record commences quietly and then abruptly shows an extended series which reached 12 mm. in amplitude. It then gradually subsides into small, slow throws which last to the center of the record. Just after this there is a short series of 10 mm. throws, which tapers off to 5 mm. throws, continuing to the end of the record. Type 9 (2) plus.

Record 59. Punched right eye of animal with pencil. Animal blinked and shook head. Electrode: lft. upper mid. med. forebrain. The record shows a series, just after starting, which commences abruptly and reaches 11 mm. amplitude. Then it gradually scatters and decreases in amplitude until small activity of 5 mm. amplitude is reached. The last half of the record is quiet. Type 8 (2) plus.

Record 60. Sounded quincke tube into right ear of animal. Animal blinked three times. Electrode: rt. upper ant. med. forebrain. The record shows scattered throws of 5 and 6 mm. throughout. In the center of the record there is a short series of 7 mm. amplitude. Type 13 (1).

Record 61. Sounded quincke tube into right ear of animal. Animal blinked twice. Electrode: lft. upper mid. med. forebrain. The record shows scattered throws of 5 and 6 mm. throughout. At the end of the first fifth of the record there is a short series of 9 mm. and a second, slight longer, at the beginning of the last fourth. Type 8 (2) mimus.

Record 62. Punched animal's neck three times. Jumped each time. Electrode: lft. upper mid. med. forebrain. The record starts quietly, but abruptly emerges into a series of 10 mm. amplitude. This gradually subsides into 5 mm. activity until after the center of the record, when a series of 11 mm. amplitude occurs. A third series, of 10 mm. amplitude, occurs just before the end of the record. Type 8 (2) plus.

Record 63. Punched animal's neck three times with pencil. Animal jumped each time. Electrode: rt. upper ant. med. forebrain. The record shows a short series at the very first, of 8 mm. amplitude. In the center of the record there is a series of 9 mm. amplitude. In the last fifth of the record there is a third series of 8 mm. amplitude, which is quite short. Type 8 (2).

Record 64. Punched animal's bill three times. Animal jumped each time. Electrode: rt. upper ant. med. forebrain. The record commences with a series of 10 mm. throws, which gradually tapers off. At the end of the first third of the record there occurs another series which reaches 10 mm. amplitude abruptly, and then tapers off, rhythmically, into slow throws. At the

beginning of the last third of the record there is a third abrupt series, which reaches 14 mm. amplitude. Type 9 (2) plus.

Record 65. Punched animal's bill three times with pencil. Animal jumped and winced each time. Electrode: lft. upper mid. med. forebrain. The record shows a series, just after the start, which reached 17 mm. amplitude abruptly, and then tapers off gradually to 5 mm. throws. In the center of the record there is another series, of 17 mm. amplitude, abrupt which tapers off gradually to small 8 mm. slow throws. The last third of the record shows a third series, extended, which commences abruptly at 16 mm. and then tapers off gradually to the end of the record, with slow throws. Type 5 (4).

Record 66. Hit foot with pencil, twice. Animal jumped and curled feet. Electrode: lft. upper mid. med. forebrain. The record starts quietly but soon shows a short series of 9 mm. amplitude, which tapers off into scattered throws of 5 mm. At the beginning, of the last third of the record there is a second short series of 8 mm. amplitude. Type 8 (2) minus.

Record 67. Hit feet with pencil twice. Animal jumped and curled feet. Electrode: rt. upper ant. med. forebrain. The record commences quietly for 50 mm. but at this point shows a short series of 8 mm. amplitude. The remainder of the record shows scattered activity of 5 mm. Type 8 (2) minus.

Pigeon U May 10, 9:00 p.m.

Description of Records:

Record 1. Animal quiet. Electrode: upper rt. mid. med. forebrain. The record is slightly irregular, with scattered throws of 5 mm. height. Type 13 (1).

Record 2. Animal quiet. Electrode: lft. anterior lateral forebrain. The record is negative. Type 1 (0).

Record 3. Closed circuit. Record negative. Type 1 (0).

Record 4. Punched rt. eye with pencil. Animal blinked, jumped and knocked electrode off shortly after recording started. Electrode: rt. upper mid. med. forebrain. The record begins with a series of fast throws of 10 mm. height. These throws ranging, up to 15 mm. in height, are scattered, throughout the record, in between the slow throws of 40 mm. amplitude, which mark the slipping of the electrode. Type 11 (4).

Record 5. Punched rt. eye with pencil. Animal blinked and winced slightly. Electrode: lft. ant. lat. forebrain. There is one short series of throws, in the center of the record, which are 10 mm. in height. The rest of the record is negative. Type 6 (2).

Record 6. Punched rt. eye with pencil. Animal blinked and winced slightly. Electrode: rt. upper mid. med. forebrain. Record shows a series, 50 mm. long, with throws which reach 12 mm. in height. The remainder of the record is quiet. Type 6 (2).

Record 7. Pulled animal's tail. Seemingly passive. Electrode: rt. upper mid. med. forebrain. Record is fairly quiet with irregular throws of 5 mm. height. Type 13 (1).

Record 8. Pulled animal's tail. Slight wincing. Electrode: lft. ant. lat. forebrain. Record is fairly quiet with a few irregular throws of 5 mm. height, scattered throughout. Type 13 (1).

Record 9. Punched animal's neck with pencil. Animal passive. Electrode: lft. ant. lat. forebrain. Record is negative. Type 1 (0).

Record 10. Punched bill with pencil. Pigeon jumped and removed electrode before record was finished. Electrode: rt. upper mid. med. forebrain. First part of record is negative. At the center, small throws of 5 mm. amplitude commence. These gradually increase up to 30 mm. amplitude. Then the slow throws appear, showing that the electrode slipped. Type 4 (4).

Record 11. Punched bill with pencil. Animal remained passive. Electrode: lft. ant. lat. forebrain. The record is rough in appearance with a scattering of small 5 mm. throws. Type 13 (1).

Record 12. Animal quiet. Electrode: rt. lower mid. med. forebrain. Record negative. Type 1 (0).

Record 13. Animal quiet. Electrode: lft. mid. lat. forebrain. Record shows scattered throws of 5 mm. amplitude. Type 13 (1).

Record 14. Punched rt. eye with pencil. Animal blinked and winced slightly. Electrode: lft. mid lat. forebrain. The record contains one series, 40 mm. in length in the center of the record which gradually attains 15 mm. amplitude and then gradually subsides. Type 5 (4).

Record 15. Punched rt. eye with pencil. Animal blinked and winced. Electrode: rt. lower mid. med. forebrain. Throws of high frequency commence soon after the record started and gradually increase, in the form of a series, up to 20 mm. amplitude. This series gradually subsides, but the record continues rough to the end. Type 3 (4).

Record 16. Animal quiet. Electrode: rt. lower mid. med. forebrain. Record negative. Type 1 (0).

Record 17. Hit animal's feet with a pencil. Animal struggled slightly. Electrode: rt. lower mid. med. forebrain. Just before the middle of the record there occurs a short series of

throws of 13 mm. amplitude. The remainder of the record is rough, with throws of 5 mm. height. Type 2 (4).

Record 18. Hit animal's feet with pencil. Animal struggled. Electrode: lft. mid. lat. forebrain. The first two thirds of the record are irregularly scattered, with throws of 5 mm. amplitude. The last third shows two series which reach 14 mm. in height. Type 2 (4).

Record 19. Hit animal's feet. Struggled slightly and moved head a little. Electrode: rt. lower mid. med. forebrain. The record is rough throughout, with scattered throws of 5 mm. Shortly after the beginning of the record there is a short series with throws of 9 mm. height. Type 8 (2).

Record 20. Quincke tube was blown into rt. ear. Animal jumped slightly. Electrode: rt. lower mid. med. forebrain. The record is rough throughout, with small throws of 5 mm. amplitude. Type 13 (1).

Record 21. Quincke Tube was blown into rt. ear. Animal jumped slightly. Electrode: lft. mid. lat. forebrain. There are small throws of 5 mm. height scattered throughout. Type 13 (1).

Record 22. Animal quiet. Electrode: rt. post. med. lft. forebrain. Record is negative. Type 1 (0).

Record 23. Animal quiet. Electrode: lft. upper mid. med. forebrain. Record is negative. Type 1 (0).

Record 24. Punched rt. eye with pencil. Animal blinked and winced slightly. Electrode: lft. upper mid. med. forebrain. The record begins quietly, but a series starts, graduating to 12 mm. then slowly subsides. The remainder of the record is rough, interspersed with throws of 5 and 6 mm. height. Type 3 (4).

Record 25. Punched rt. eye with pencil. Animal blinked and jumped vigorously, so that electrode came off toward end of record. Electrode: rt. post. med. lft. forebrain. The first part of the record is quiet, but a series begins which increases gradually to 15 mm. This series ends when the electrode slips off, but continues after the electrode settles again upon the cortex. The last fourth of the record is smooth. Type 3 (4).

Record 26. Hit feet. Animal winced and struggled slightly. Electrode: rt. post. med. lft. forebrain. There is a short series after the record started, which reaches a maximum of 12 mm. Type 8 (2).

Record 27. Hit feet with pencil. Winced and struggled after record was over. Electrode: lft. upper mid. med. forebrain. The record shows small 5 mm. throws scattered irregularly toward the end of the record. Type 13 (1).

Record 28. Quincke tube blown into rt. ear after record started. Animal passive. Electrode: lft. upper mid. med. forebrain. The

record shows scattered throws of 5 mm. throughout. Type 12 (1).

Record 29. Quincke tube blown into rt. ear after record started. Animal winced slightly. Electrode: rt. post. med. lft. forebrain. The record shows small groups and scattered throws of 10 mm. There are three major groups. Type 8 (2).

Record 30. Animal quiet. Electrode: rt. post. med. rt. forebrain. The record is negative. Type 1 (0).

Record 31. Animal quiet. Electrode: lft. post. lat. forebrain. The record shows scattered throws of 5 mm. amplitude. Type 13 (1).

Record 32. Hit rt. eye with pencil. Animal blinked and winced. Electrode: lft. post. lat. forebrain. The beginning of the record is quiet. Then a series starts, gradually reacting 10 mm., to subside. Another series then begins, this time 40 mm. in amplitude. A third series of 10 mm. amplitude occurs toward the center of the record. The latter half of the record is quiet. Type 11 (4).

Record 33. Hit rt. eye twice with pencil. Animal winced and blinked. Electrode: rt. post. med. rt. forebrain. There is a short series at the beginning of the record, which reaches 8 mm. in amplitude. The record is then quiet until just after the first half, when a second series, 60 mm. in duration, commences. Here the amplitude is 10 mm. for the highest throws. The throws are irregular, but gradually subside in size, after a fairly abrupt beginning. Type 3 (4).

Record 34. Hit animal's feet with pencil. Animal struggled. Electrode: rt. post. med. rt. forebrain. The first part of the record is quiet, save for scattered throws of 5 mm. amplitude. Shortly after the middle of the record, there begins a series, of 40 mm. duration, with throws of 10 mm. Type 3 (4).

Record 35. Hit animal's feet with pencil. Struggled vigorously. Electrode: lft. post. lat. forebrain. Shortly after the beginning of the record there occurs a very short series which reaches an amplitude of 25 mm. This is followed by a quiet period, then by a short series, of 15 mm. height. Irregular throws of 10 mm. are next scattered through a section of the record, some of which form a short series. The last half of the record is an extended series, with throws ranging up to 15 mm. in height. These are fast and continue nearly to the end of the record. Type 11 (4).

Record 36. Quincke tube was blown in the rt. ear after the record started. Animal passive. Electrode: lft. post. lat. forebrain. The record shows scattered throws of 5 mm. amplitude, throughout. Toward the middle of the record, in 3 places, these are grouped into rhythms of four impulses each. Type 13 (1).

Record 37. Quincke tube was blown in the rt. ear after the record started. Animal winced. Electrode: rt. post. med. rt. forebrain. The record shows two types of volleys, one which ranges at the end of the first third of the record to 10 mm. in amplitude. The other type is only 5 mm. in height. There are two of these latter types, one in the first and one in the last third of the record. Type 8 (2).

Record 38. Animal quiet. Electrode: rt. post. lat. forebrain. The record is negative. Type 1 (0).

Record 39. Animal quiet. Electrode: lft. ant. med. lower forebrain. The record is negative. Type 1 (0).

Record 40. Hit rt. eye with pencil. Animal winced slightly. Electrode: lft. ant. med. lower forebrain. The record commences with no activity. At the end of the first third, a series begins, which reaches 10 mm. in amplitude. The remainder of the record is quiet. Type 9 (2).

Record 41. Hit rt. eye with pencil. Animal winced and blinked. Electrode: rt. post. lat. forebrain. The beginning of the record shows a series of 70 mm. duration. It starts fairly abruptly and reaches 17 mm. This gradually subsides. The remainder of the record shows series of 5 mm. amplitude. Type 3 (4).

Record 42. Hit animal's feet with pencil. Animal struggled. Electrode: rt. post. lat. forebrain. The first fourth of the record is quiet. At this point a short series commences, of 12 mm. amplitude. This lasts for thirty mm. The remainder of the record shows scattered throws of 5 mm. amplitude. There is the beginning of a series at the end of the record. Type 3 (4).

Record 43. Hit animal's feet with pencil. Animal struggled. Electrode: lft. ant. med. lower forebrain. The first third of the record is quiet. At this point there begins a short series of 5 mm. amplitude. This is followed by one throw of 10 mm. Then there occurs a fairly long series of small throws, then another large one, then scattered small throws. Type 3 (4).

Record 44. Quincke tube was blown into animal's rt ear after record started. Animal passive. Electrode: lft. ant. med. lower forebrain. The record is negative. Type 1 (0).

Record 45. Quincke tube blown in the rt. ear of animal after record started. Animal jumped slightly. Electrode: rt. post. lat. forebrain. The beginning of the record shows a series of spaced throws of 8 mm. amplitude. These gradually subside and there occurs a short series which has throws of 12 mm. amplitude. There follows an inactive portion of the record. The last fourth shows a series with throws of 5 and 8 mm. amplitude. Type 8 (2).

Record 46. Hit feet with pencil. Animal struggled slightly.

Electrode: rt. post. lat. forebrain. The record shows two types of activity. There are two separate throws of 11 mm. amplitude. These are interspersed with throws of 5 mm. amplitude. Type 8 (2).

Record 47. Hit head with pencil. Animal jumped slightly and raised head. Electrode: lft. ant. med. lower forebrain. There is a series of 5 mm. throws at the first of the record, another in the center of the record, and one just before the close. Type 9 (2).

Record 48. Hit feet with pencil. Animal struggled slightly and raised head. Electrode: lft. ant. med. lower forebrain. The record shows two short series of 5 mm. height. There are throws of 5 mm. scattered irregularly throughout. Type 13 (1).

Record 49. Animal quiet. Electrode: rt. ant. forebrain. The record is negative. Type 1 (0).

Record 50. Hit rt. eye with pencil. Animal jumped so that electrode slipped at first of record. Electrode: rt. ant. forebrain. The record begins with a series of 10 mm. throws, which are broken by the slow throws of the slipping electrode. Following this movement there is a large series which ranges to 23 mm. This series gradually subsides. Type 11 (4).

Record 51. Hit feet with pencil. Animal struggled. Electrode: rt. ant. forebrain. The record begins with a series 8 mm. in amplitude. Series of this size are scattered throughout the record. At the very end of the record a series of 16 mm. occurs. Type 2 (4).

Record 52. Quincke tube was blown in the rt. ear. Animal jumped slightly. Electrode: rt. ant. forebrain. The beginning of the record has scattered throws of 5 mm. amplitude. At the end of the first third of the record there occurs a short series of 10 mm. amplitude. The remainder of the record is quiet. Type 4 (4).

Pigeon BB June 11, 1933, 10:00 p.m.

Description of Records:

Record 1. Animal passive. Electrode: rt. upper mid. med. forebrain. The record is negative. Type 1 (0).

Record 2. Animal passive. Electrode: rt. upper ant. med. forebrain. The record is negative. Type 1 (0).

Record 3. Punched animal'r right eye with pencil. Animal blinked. Electrode: rt. upper ant. med. forebrain. The record begins with a series which reached 16 mm. in amplitude and then tapers off into 8 mm. activity. The very last part of the record is negative. Type 5 (4).

Record 4. Punched animal's right eye with pencil. Animal blinked and jerked. Electrode: rt. upper mid. med. forebrain. The first 35 mm. of the record are negative. Then there starts fairly gradually a series which reaches 20 mm. in amplitude and continues irregularly to the end of the record. Type 5 (4).

Record 5. Sounded quincke tube into right ear of animal. Animal passive. Electrode: rt. upper mid. med. forebrain. The record shows one throw in the first third. Type 13 (1).

Record 6. Sounded quincke tube into right ear of animal. Animal blinked. Electrode: rt. upper ant. med. forebrain. The record shows a short series of 8 mm. throws toward the first of the record, which are very fast and rather regular. Type 8 (2).

Redord 7. Blew at animal's head. Animal jerked. Electrode: rt. upper mid. med. forebrain. Just after the start of the record there is an extended series which reaches 16 mm. in amplitude. This series begins fairly abruptly, then tapers off more gradually. The last 50 mm. of the record are quiet. Type 5 (4).

Record 8. Blew at animal's head. Animal jerked slightly, but not as much as before. Electrode: rt. upper ant. med. forebrain. The record shows a short series just after the beginning of the record, which reaches 10 mm. in amplitude. The last half of the record is quiet. Type 9 (2).

Record 9. Animal passive in the dark. Electrode: rt. upper ant. med. forebrain. The record is negative. Type 1 (0).

Record 10. Animal passive in the dark. Electrode: rt. upper mid. med. forebrain. The record is negative. Type 1 (0).

Record 11. Shined on room light after record started. Animal passive. Electrode: rt. upper mid. med. forebrain. The record is quiet except for one short series of throws of 6 mm. amplitude. Type 13 (1).

Record 12. Shined light in room after record started. Animal passive. Electrode: rt. upper ant. med. forebrain. The record is negative. Type 1 (0).

Record 13. Punched animal's bill with pencil. Animal wriggled. Electrode: rt. upper ant. med. forebrain. Shows a short series at the beginning of the record which reaches 10 mm. amplitude. At the end of the record there is a slightly longer series which also reaches 10 mm. amplitude. Type 8 (2).

Record 14. Punched animal's bill with pencil. Animal wriggled and finally struggled enough to move electrode at end of the record. Electrode: rt. upper mid. med. forebrain. The record shows at the first the end of a series of 10 mm. throws. Beginning with the center of the record there is a series which reaches 15 mm. for a short duration then mounts to 40 mm. amplitude. The last third of the record shows the slow throws of

the moving electrode. Type 11 (4).

Record 15. Animal passive. Electrode: rt. lower ant. med. forebrain. The record is negative. Type 1 (0).

Record 16. Animal passive. Electrode: rt. ant. lat. forebrain. The record is negative. Type 1 (0).

Record 17. Sounded quincke tube into right ear of animal. Animal blinked. Electrode: rt. ant. lat. forebrain. The record is negative. Type 1 (0).

Record 18. Sounded quincke tube into right ear of animal. Animal blinked. Electrode: rt. lower ant. med. forebrain. The record is negative. Type 1 (0).

Record 19. Punched right eye of animal with pencil. Animal blinked. Electrode: rt. lower ant. med. forebrain. The record starts with a series which reaches 10 mm. in amplitude. This gradually tapers off so that the last half of the record is negative. Type 8 (2).

Record 20. Punched right eye of animal with pencil. Animal blinked and jumped so as to move electrode. Electrode: rt. ant. lat. forebrain. The record starts with a series at 10 mm. amplitude which mounts abruptly to 25 mm. This series is followed by the slow throws of the electrode movement. The last two thirds of the record show activity of 10 mm. amplitude. Type 11 (4).

Record 21. Punched animal's bill with pencil. Animal jumped slightly. Electrode: rt. ant. lat. forebrain. The record shows a few scattered throws of 7 mm. amplitude. Type 13 (1).

Record 22. Punched animal's bill with pencil. Animal jumped. Electrode: rt. lower ant. med. forebrain. The record shows a series which reaches 10 mm. just after the beginning of the record. This is followed in the center of the record by another series. Toward the end of the record there is a short series of abrupt throws which reaches 20 mm. amplitude. Type 2 (4).

Record 23. Animal passive. Electrode: rt. post. rt. med. forebrain. The record is negative. Type 1 (0).

Record 24. Animal passive. Electrode: rt. lower mid. med. forebrain. The record is negative. Type 1 (0).

Record 25. Blew at animal. Animal jumped. Electrode: rt. lower mid. med. forebrain. The record commences with an abrupt series which reaches 14 mm. in amplitude. This series lasts until the middle of the record, tapering off very gradually. The last of the record is negative. Type 9 (2) plus.

Record 26. Blew at animal. Animal blinked and jumped. Electrode: rt. post. rt. med. forebrain. The record is quiet for the first 15 mm. then there starts, abruptly, a series which

reaches 20 mm. This series gradually tapers off, but there is small activity to the end of the record. Type 5 (4).

Record 27. Sounded quincke tube into right ear of animal. Animal blinked. Electrode: rt. post. rt. med. forebrain. The record is negative. Type 1 (0).

Record 28. Sounded quincke tube into right ear of animal. Animal blinked and jumped. Electrode: rt. lower mid. med. forebrain. The record shows activity of 7 mm. amplitude scattered irregularly throughout the record. Type 13 (1).

Record 29. Punched animal's right eye with pencil. Animal blinked and winced. Electrode: rt. lower mid. med. forebrain. The record starts with an abrupt series which reaches 20 mm. and then gradually tapers off throughout the whole record, showing mostly 10 mm. throws. Type 5 (4).

Record 30. Punched animal's right eye with pencil. Animal blinked and winced. Electrode: rt. post. rt. med. forebrain. The record starts with a series which reaches 30 mm. This series is quite short and ends fairly abruptly. The last two thirds of the record are quiet. Type 4 (4).

Record 31. Punched animal's bill twice with pencil. Animal jumped. Electrode: rt. post. rt. med. forebrain. The record starts with a 10 mm. series which ends abruptly, with one throw of 30 mm. Beginning with the center of the record there is a second series of 10 mm. throws which also ends in a 20 mm. throw. The last section of the record is quiet. Type 2 (4).

Record 32. Punched animal's bill with pencil. Animal jumped. Electrode; rt. lower mid. med. forebrain. The record is quiet to start with, but soon shows a fairly long series of 10 mm. amplitude. The last half of the record is quiet. Type 8 (2).

Record 33. Pulled animal's tail three times. Animal winced each time. Electrode: rt. lower mid. med. forebrain. The first half of the record is quiet. In the last half there are three short series of throws which are abrupt, both in onset and in termination and are fast, reaching an amplitude of 10 mm. Type 8 (2).

Record 34. Pulled animal's tail. Animal winced. Electrode: rt. post. rt. med. forebrain. The record shows a few scattered throws of 5 mm. amplitude. Type 13 (1).

Record 35. Animal passive. Electrode: rt. post. lat. forebrain. The record is negative. Type 1 (0).

Record 36. Animal passive. Electrode: rt. mid. lat. forebrain. The record is negative. Type 1 (0).

Record 37. Punched animal's right eye with pencil. Animal

blinked; jumped sufficiently to remove electrode. Electrode: rt. mid. lat. forebrain. The record starts with a large series which reaches 40 mm. This is followed by the slow throws indicating movement of the electrode, and the last of the record shows the electrode off. Type 4 (4).

Record 38. Punched animal's right eye with pencil. Animal blinked and winced. Electrode: rt. post. lat. forebrain. The record is a continuous series of 10 mm. amplitude. Type 9 (2).

Record 39. Blew at animal. Animal blinked and jerked. Electrode: rt. post. lat. forebrain. The record starts with a series which reaches 20 mm. amplitude and the gradually tapers off to the center of the record. The last half is negative. Type 5 (4).

Record 40. Blew at animal. Animal blinked, jumped and removed electrode. Electrode: rt. mid. lat. forebrain. The record commences quietly. There then appears a series of 10 mm. amplitude. This is followed by abrupt activity at the 45 mm. amplitude. This later is interspersed with the slow throws denoting the movement of the electrode. Type 5 (4).

Record 41. Pulled animal's tail. Animal passive. Electrode: rt. mid. lat forebrain. The record is negative. Type 1 (0).

Record 42. Pulled animal's tail. Animal passive. Electrode: rt. post. lat. forebrain. The record is negative. Type 1 (0).

Record 43. Closed circuit. The record is negative. Type 1 (0).

Pigeon GG June 31, 1933, 8:00, 9:30 p.m.

Description of Records:

Record 1. Closed circuit. The record is negative. Type 1 (0).

Record 2. Animal was quiet in the room light. Electrode: lft. lower mid. med. forebrain. The record is negative. Type 1 (0).

Record 3. Animal was passive in the room light. Electrode: rt. ant. forebrain. In the last half of the record there is irregular activity which reaches 7 mm. in amplitude. Type 13 (1).

Record 4. The animal was passive in the dark. Electrode: rt. ant. forebrain. The record is negative. Type 1 (0).

Record 5. The animal was passive in the dark. Electrode: lft. upper mid. med. forebrain. The record was negative. Type 1 (0).

Record 6. The animal was passive in the dark. Electrode: rt. lower mid. med. forebrain. The record shows regular small activity of 6 mm. throughout. Type 12 (1).

Record 7. The animal was passive in the dark. Electrode: left lower mid. med. forebrain. The record is negative. Type 1 (0).

Record 8. The animal was passive in the dark. Electrode: rt. post. left. med. forebrain. The record is negative. Type 1 (0).

Record 9. The animal was passive in the dark. Electrode: left post. rt. med. forebrain. The record shows irregular small throws of 5 and 6 mm. amplitude throughout the record. Type 13 (1).

Record 10. The animal was passive in the dark. Electrode: rt. post. rt. med. forebrain. In the first half of the record there is a fairly long series which reaches 10 mm. in amplitude. Type 9 (2).

Record 11. The animal was passive in the dark. Electrode: left ant. lat. forebrain. The record is negative. Type 1 (0).

Record 12. The animal was passive in the dark. Electrode: rt. mid. lat. forebrain. The record is negative. Type 1 (0).

Record 13. The animal was passive in the dark. Electrode: lft. mid. lat. forebrain. The record was negative. Type 1 (0).

Record 14. The animal was passive in the dark. Electrode: rt. post. lat. forebrain. The record shows irregular throws of 5 mm. throws. Type 13 (1).

Record 15. Punched animal's neck with pencil. Animal passive. Electrode: left ant. forebrain. The record is negative. Type 1 (0).

Record 16. Punched animal's neck with pencil. Animal passive. Electrode: rt. ant. forebrain. The record is negative. Type 1 (0).

Record 17. Punched animal's neck with pencil. Animal passive. Electrode: left lower ant. med. forebrain. The record is negative. Type 1 (0).

Record 18. Punched animal's neck with pencil. Animal passive. Electrode: rt. upper ant. med. forebrain. The record shows regular small throws of 5 mm. amplitude scattered throughout. Type 12 (1).

Record 19. Punched animal's neck with pencil. Animal passive. Electrode: left upper mid. med. forebrain. The record is negative. Type 1 (0).

Record 20. Punched animal's neck with pencil. Animal passive. Electrode: rt. lower ant. med. forebrain. The record is negative. Type 1 (0).

Record 21. Punched animal's neck with pencil. Animal passive. Electrode: lft. post. lft. med. forebrain. The record shows

scattered throws of 5 mm. amplitude throughout. Type 13 (1).

Record 22. Punched animal's neck with pencil. Animal passive. Electrode: rt. upper mid. med. forebrain. The record shows scattered irregular throws of 5 and 6 mm. amplitude. Type 13 (1).

Record 23. Punched animal's neck with pencil. Animal passive. Electrode: lft. post. rt. med. forebrain. The record is negative. Type 1 (0).

Record 24. Punched animal's neck with pencil. Animal passive. Electrode: rt. post. lft. med. forebrain. The record shows irregular throws of 6 and 7 mm. amplitude throughout the record. Type 13 (1).

Record 25. Punched animal's neck with pencil. Animal passive. Electrode: lft. mid. lat. forebrain. The record is negative. Type 1 (0).

Record 26. Punched animal's neck with pencil. Animal passive. Electrode: left post. lat. forebrain. The record shows scattered throws of 5 mm. amplitude. Type 13 (1).

Record 27. Punched animal's bill with pencil. Animal winced. Electrode: rt. ant. forebrain. The record shows two fairly long series which reach 45 mm. in amplitude, one in the center of the record and the other at the end. Type 5 (4).

Record 28. Punched animal's bill with pencil. Animal winced. Electrode: rt. ant. forebrain. The record shows a fairly long series of 10 mm. throws. Type 9 (2).

Record 29. Punched animal's bill with pencil. Animal winced. Electrode: lft. upper ant. med. forebrain. There are two short series of 9 mm. throws in the last half of the record. Type 8 (2).

Record 30. Punched animal's bill with pencil. Animal winced. Electrode: left lower mid. med. forebrain. There is a long series of 10 mm. throws in the middle of the record. Type 9 (2).

Record 31. Punched animal's bill with pencil. Animal winced. Electrode: left. post. left med. forebrain. The record shows a short series of 9 mm. throws, in the first half of the record. Type 8 (2).

Record 32. Punched animal's bill with pencil. Animal winced. Electrode: left ant. lat. forebrain. The record shows a long series of 9 mm. amplitude throws, which extend practically throughout the record. Type 7 (2).

Record 33. Punched animal's bill with pencil. Animal winced. Electrode: left mid. lat. forebrain. The record shows a short

series which reaches 15 mm. in amplitude, in the center of the record. Type 4 (4).

Record 34. Punched animal's bill with pencil. Animal winced. Electrode: left post. lat. forebrain. There are two abrupt, short series which reach 10 mm. in amplitude, one in the center and one at the end of the record. Type 8 (2).

Record 35. Punched animal's back with pencil. Animal winced and wriggled. Electrode: rt. ant. forebrain. The record shows a very short and abrupt series just after the record started which reaches 50 mm. in amplitude. Type 2 (4).

Record 36. Punched animal's back with pencil. Animal winced. Electrode: left lower ant. med. forebrain. Just after the record started there is a long series of 10 mm. amplitude throws. Type 9 (2).

Record 37. Punched animal's back with pencil. Animal winced. Electrode: left lower mid. med. forebrain. The record shows a short series of 9 mm. amplitude at the end of the record. Type 8 (2).

Record 38. Punched animal's back with pencil. Animal winced. Electrode: left post. rt. med. forebrain. The record shows a short series of 9 mm. amplitude throws in the center of the record. Type 8 (2).

Record 39. Punched animal's back with pencil. Animal winced. Electrode: left mid. lat. forebrain. The record shows two long series of 9 mm. amplitude throws. One of these is at the very beginning of the record and the other in the last third. Type 9 (2).

Record 40. Punched animal's back with pencil. Animal winced. Electrode: rt. post. lat. forebrain. There is a long series of 9 mm. throws in the record. Type 9 (2).

Record 41. Hit animal's back with pencil. Animal winced. Electrode: rt. post. lft. med. forebrain. The record shows a long series of 9 mm. amplitude in the first third of the record. Type 9 (2).

Record 42. Blew at animal. Animal winced. Electrode: rt. ant. lat. forebrain. The record shows two fairly long series which reach 16 mm. in amplitude, one in the first half of the record and the other in the last half. Type 5 (4).

Record 43. Blew at animal. Animal winked. Electrode: rt. post. lft. med. forebrain. The record shows two fairly short series which reach 50 mm. in amplitude. The first of these is located at the end of the first third of the record, the other in the last third. Type 4 (4).

Record 44. Blew at animal. Animal winked. Electrode: rt.

lower ant. med. forebrain. The record shows three fairly long series which reach 15 mm. in amplitude. Type 5 (4).

Record 45. Blew at animal. Animal winked. Electrode: rt. ant. forebrain. There are three fairly long series in the record which reach 12 mm. in amplitude. Type 9 (2).

Record 46. Sounded quincke tube into right ear of animal. Animal blinked. Electrode: rt. upper mid. med. forebrain. The record shows small throws of 6 and 7 mm. amplitude, irregularly scattered through the record. Type 13 (1).

Record 47. Sounded quincke tube into right ear of animal. Animal blinked. Electrode: rt. mid. lat. forebrain. The record shows irregular throws of 6 and 7 mm. amplitude. Type 13 (1).

Record 48. Sounded quincke tube into right ear of animal. Animal blinked. Electrode: left ant. lat. forebrain. The last half of the record shows a fairly long series which reaches 15 mm. in amplitude. Type 5 (4).

Record 49. Sounded quincke tube on right side of animal. Animal blinked. Electrode: left post. lat. forebrain. The record shows regular throws of 5 mm. in amplitude. Type 12 (1).

Record 50. Sounded quincke tube into right ear of animal. Animal blinked. Electrode: left post. left. med. forebrain. The record shows irregular throws of 6 and 7 mm. amplitude scattered throughout. Type 13 (1).

Record 51. Sounded quincke tube into right ear of animal. Animal blinked. Electrode: left lower mid. med. forebrain. The record shows regular throws of 6 mm. amplitude throughout the record. Type 12 (1).

Record 52. Sounded quincke tube into right ear of animal. Animal blinked. Electrode: left lower ant. med. forebrain. The record shows irregular throws of 6 and 7 mm. amplitude. Type 13 (1).

Record 53. Shined flashlight into animal's eyes. Animal passive. Electrode: left lower mid. med. forebrain. The record is negative. Type 1 (0).

Record 54. Shined flashlight into animal's eye. Animal passive. Electrode: left post. rt. med. forebrain. The record shows irregular throws of 5 and 6 mm. amplitude. Type 13 (1).

Record 55. Shined flashlight into animal's eyes. Animal passive. Electrode: left ant. lat. forebrain. The record shows irregular throws of 6 and ;7 mm. amplitude scattered throughout the record. Type 13 (1).

Record 56. Shined flashlight into animal's eyes. Animal passive. Electrode: left mid. alt. forebrain. The record shows regular throws of 6 mm. amplitude throughout. Type 12 (1).

Record 57. Shined flashlight into animal's eyes. Animal passive. Electrode: rt. ant. forebrain. In the center of the record there is a short series which reaches 10 mm. in amplitude. Type 8 (2).

Record 58. Shined flashlight into animal's eye. Animal passive. Electrode: rt. lower mid. med. forebrain. The record shows irregular throws of 5 and 6 mm. amplitude, throughout. Type 13 (1).

Record 59. Shined flashlight into animal's eyes. Animal passive. Electrode: rt. post. lft. med. forebrain. The record shows irregular throws of 5 and 6 mm. amplitude, throughout. Type 13 (1).

Record 60. Shined flashlight into animal's eyes. Animal passive. Electrode: rt. post. rt. med. forebrain. The record shows a long series of 9 mm. throws, which extends almost the full length of the record. Type 9 (2).

Record 61. Shined light into animal's eyes. Animal was passive. Electrode: rt. mid. lat. forebrain. The record shows irregular throws which reached 7 and 8 mm. in amplitude. Type 13 (1).

Record 62. Shined flashlight into animal's eyes. Animal passive. Electrode: rt. post. lat. forebrain. The record shows irregular throws of 6 and 7 mm. amplitude throughout. Type 13 (1).

Record 63. Hit aniaml's feet with pencil. Animal curled feet. Electrode: rt. lower ant. med. forebrain. The record shows a short series of 9 mm. throws. Type 8 (2).

Record 64. Hit animal's feet with pencil. Animal curled feet. Electrode: rt. upper mid. med. forebrain. The record shows scattered throws of 5 and 6 mm. amplitude. Type 13 (1).

Record 65. Hit animal's feet with pencil. Animal curled feet. Electrode: rt. ant. lat. forebrain. The record shows regular throws of 5 mm. amplitude throughout the record. Type 12 (1).

Record 66. Hit animal's feet with pencil. Animal curled feet. Electrode: rt. mid. lat. forebrain. The record shows irregular small activity throughout. Superimposed on this are two short series which reach 15 mm. in amplitude. The larger of these is in the center of the record. Type 4 (4).

Record 67. Hit animal's feet with pencil. Animal curled feet. Electrode: left upper ant. med. forebrain. The record shows a short series of 15 mm. amplitude superimposed on small activity. Type 4 (4).

Record 68. Hit animal's feet with pencil. Animal curled feet. Electrode: left ant. forebrain. The record shows irregular extended activity throughout. The throws reach 40 mm. in amplitude. The record is more active in the first than in the last half. Type 11 (4).

Record 69. Hit animal's feet with pencil. Animal curled feet and wriggled. Electrode: left lower mid. med. forebrain. The record shows extended irregular throws which reach 40 mm. in amplitude. The last half of the record is the most active. Type 11 (4).

Record 70. Hit animal's feet with pencil. Animal curled feet. Electrode: left post. lft. med. forebrain. The record shows a long series of 9 mm. throws which extend for the length of the record. Type 7 (2).

Record 71. Hit animal's feet with pencil. Animal curled feet. Electrode: left ant. lat. forebrain. The record shows a regular series of 9 mm. throws, which is very long. Type 7 (2).

Record 72. Animal struggled spontaneously. Electrode: left upper ant. med. forebrain. The record shows extended irregular throws which reach 30 mm. in amplitude. Type 11 (4).

Record 73. Animal struggled spontaneously. Electrode: left post. left med. forebrain. The record shows two fairly long series which starts gradually and then ends abruptly. The throws reach 40 mm. in amplitude. One of these series is in the first half and the other in the last half of the record. Type 5 (4).

Record 74. Animal struggled spontaneously. Electrode: left ant. lat. forebrain. The record shows a fairly long series which reaches 15 mm. in amplitude. This series is mostly in the first half of the record. Type 5 (4).

Record 75. Animal struggled spontaneously. Electrode: left mid. lat. forebrain. The record shows a long series which lasts throughout the record and which reaches 30 mm. in amplitude. Type 5 (4).

Pigeon II July 5, 1933, 10:00 p.m.

Description of Records:

Record 1. Closed circuit. The record is negative. Type 1 (0).

Record 2. Sounded quincke tube into animal's right ear. Animal passive. Electrode: left upper ant. med. forebrain. The record shows a fairly long series of 11 mm. throws, which is irregular. Type 9 (2).

Record 3. Sounded quincke tube into animal's right ear. Ani-

mal passive. Electrode: rt. upper ant. med. forebrain. The record shows irregular throws of 5 and 6 mm. amplitude. Type 13 (1).

Record 4. Sounded quincke tube into right ear of animal. Animal passive. Electrode: left post. left med. forebrain. The record shows scattered throws of 5 and 6 mm. throughout. Type 13 (1).

Record 5. Sounded quincke tube into right ear of animal. Animal passive. Electrode: rt. lower ant. med. forebrain. The record is negative. Type 1 (0).

Record 6. Sounded quincke tube into animal's right ear. Animal passive. Electrode: left ant. lat. forebrain. The record shows a fairly long series of 12 mm. throws. Type 9 (2).

Record 7. Sounded quincke tube into animal's right ear. Animal passive. Electrode: rt. post. lat. forebrain. The record shows a fairly long series of 14 mm. throws in the first half of the record . Type 9 (2) plus.

Record 8. Sounded quincke tube into animal's right ear. Animal passive. Electrode: left mid. lat. forebrain. The record shows a short series of 9 mm. throws at the first of the record. Type 8 (2).

Record 9. Sounded quincke tube into animal's right ear. Animal passive. Electrode: rt. mid. lat. forebrain. The record shows a fairly short series of 10 mm. throws in the center. Type 8 (2).

Record 10. Sounded quincke tube in right ear. Animal passive. Electrode: rt. ant. forebrain. The record is negative. Type 1 (0).

Record 11. Quincke tube rt. ear. Passive. Electrode: left upper ant. med. forebrain. The record shows a few scattered throws of 6 and 7 mm. amplitude through the record. Type 13 (1).

Record 12. Animal struggled spontaneously. Electrode: lft. post. lat. forebrain. The record shows four abrupt series which are fairly long and reach 35 mm. in amplitude. Type 5 (4).

Record 13. Sounded 325 d.v. fork on right side of animal. Animal moved head slightly. Electrode: lft. ant. forebrain. The record shows a short series of 12 mm. amplitude at the end of the record. Type 8 (2).

Record 14. Sounded 325 d.v. fork on right side of animal. Animal moved head slightly. Electrode: lft. ant. lat. forebrain. The record shows two abrupt short series which reach 14 mm. in amplitude. One at the end of the first half, and one at the end, of the record. Type 8 (2) plus.

Record 15. Sounded 325 d.v. fork on right side of animal. Ani-

mal moved head slightly. Electrode: lft. mid. lat. forebrain. The record shows a fairly long series of 12 mm. throws. Type 9 (2).

Record 16. Sounded 325 d.v. fork on right side of animal. Animal moved head slightly. Electrode: left post. rt. med. forebrain. The record shows scattered irregular throws of 6 and 7 mm. throughout the record. Type 13 (1).

(2) Relation Between Stimulus-Response Situations and Records - From the 357 records obtained on the pigeon, there were 13 stimulus-response situations with a sufficient distribution of data to warrant description.

Kappers (26), Huber and Crosby (25) suggest that a large portion of the forebrain, the the bird, is to be regarded as 'vicarious'. In general it appears that the anterior forebrain is assumed to be olfactory, and perhaps association, in function. The upper and lower anterior medial forebrain is motor (Kalischer 38); the upper and lower middle medial forebrain are association and, to some extent, olfactory. The right and left posterior medial forebrain are visual. The posterior lateral forebrain is visual, while the anterior and middle lateral forebrain are, to some extent, association, but largely vicarious in function (Kappers, Huber and Crosby, Papez 30). Huber and Crosby comment that all structural factors "tend to diminish the possibilities of definite localization and relative independence of the forebrain centers." (p. 178-9.)

(a). Animal Passive in the Room Light. Under this behavior situation the animal was passive in ordinary room illumination. See Table XXXIII and Plate XXIV, figure 1. Examination of the map shows that the activity found, all of which is slight, occurs along the middle lateral and medial aspects of the brain.

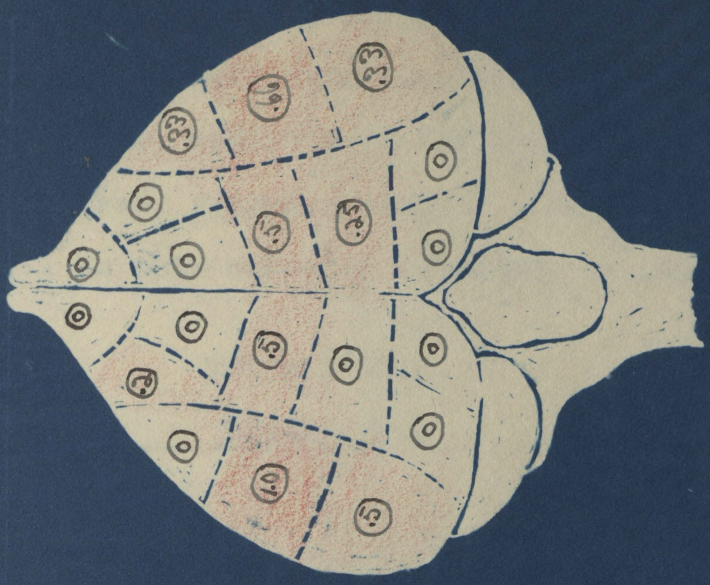

fig. 1

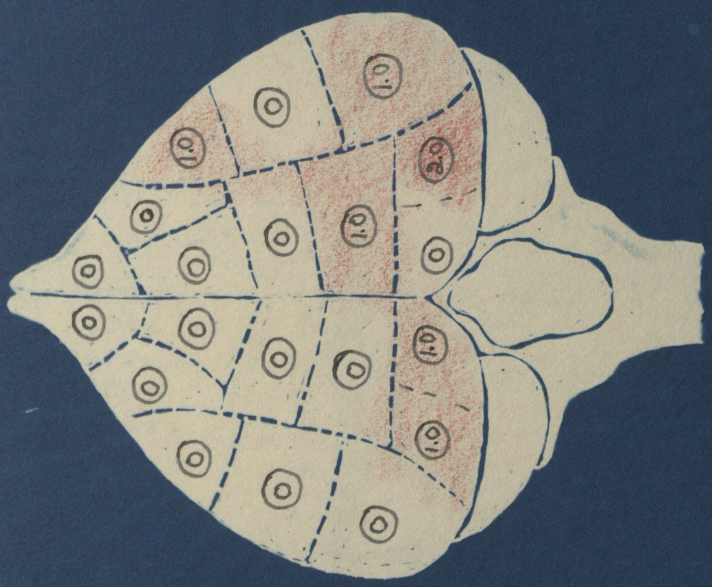

fig. 2

PLATE XXIV

It is interesting that a large part of the 'visual' region is negative. There is very slight activity in the motor region on the left side, and none on the other. The 'association' regions are very slightly active. The average magnitude for all the data on this behavior situation is .21.

Table XXXIII.

Brain Position	Record Type	Average Magnitude
RIGHT HEMISPHERE		
Ant. fore.	1, 1	0
Upper. ant. med. fore.	1, 1	0
Lower ant. med. fore.	1, 1	0
Upper mid. med. fore.	1, 13	.5
Lower mid. med. fore.	13, 1, 1, 1	.25
Post. lft. med. fore.	1, 1	0
Post. rt. med. fore.	1, 1, 1, 1	0
Ant. lat. fore.	13, 1, 1	.33
Mid. lat. fore.	13, 13, 1	.66
Post. lat. fore.	13, 1, 1	.33
LEFT HEMISPHERE		
Ant. fore.	1, 1	0
Upper ant. med. fore.	1, 1, 1, 1, 13	.2
Lower ant. med. fore.	1, 1	0
Upper mid. med. fore.	13, 1, 13, 1	.5
Lower mid. med. fore.	1, 1	0
Post. lft. med. fore.	1, 1	0
Post. rt. med. fore.	1, 1	0
Ant. lat. fore.	1	0
Mid. lat. fore.	13	1.0
Post. lat. fore.	1, 13	.5
	50 records	Average .21

(b). Animal Passive in the Dark. The next behavior situation is that of the animal passive in the dark. See Table XXXIV and Plate XXIV, figure 2. The gradient in this case occupies, at a medium and low level, the visual region, with a peak on the right side. Part of the association regions are slightly involved. Notice that, under room light, there is a definite lateral and medial gradient, while in darkness it is posterior.

This may mean that the animal was trying to see, that is, the lack of light really functioned as a 'visual' stimulus. The average magnitude for all the records under this condition is higher than for room light-- .35 as compared with .21.

Table XXXIV.

Brain Position	Record Type	Average Magnitude
RIGHT HEMISPHERE		
ant. fore.	1	0
Upper. ant. med. fore.	1	0
Lower ant. med. fore.	1	0
Upper mid. med. fore.	1	0
Lower mid. med. fore.	12	1.0
Post. lft. med. fore.	1	0
Post. rt. med. fore.	9	2.0
Ant. lat. fore.	13	1.0
Mid. lat. fore.	1	0
Post. lat. fore.	13	1.0
LEFT HEMISPHERE		
Ant. fore.	1	0
Upper ant. med. fore.	1, 1, 1, 1	0
Lower ant. med. fore.	1	0
Upper mid. med. fore.	1	0
Lower mid. med. fore.	1	0
Post. lft. med. fore.	13	1.0
Post. rt. med. fore.	13	1.0
Ant. lat. fore.	1	0
Mid. lat. fore.	1	0
Post. lat. fore.	1	0
	23 Records	Average .35

(c). Animal Passive with Flashlight Shined in Eye. In this situation a definite visual stimulus was used. The flashlight was shined in the animal's eye while the animal remained passive. See Table XXV and Plate XXV, figure 1. The map shows four peaks which have medium amplitude. These occur in the two visual areas, in the medial association region of the left hemisphere and in the olfactory region of the right anterior

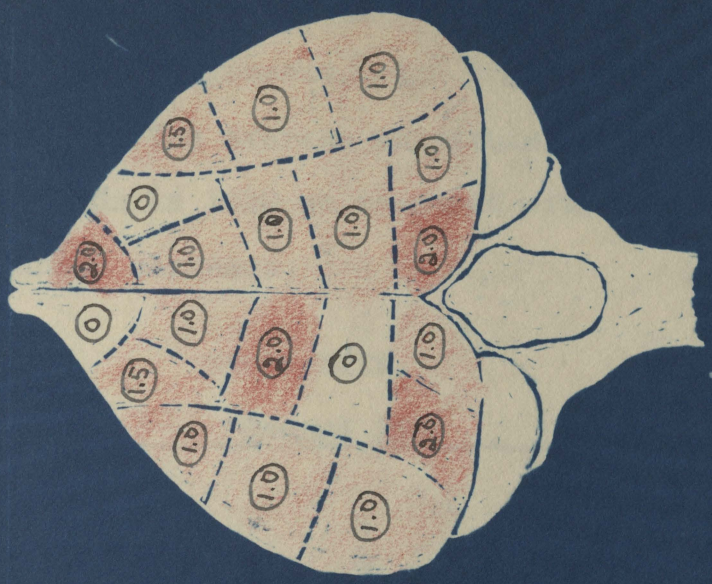

fig. 1

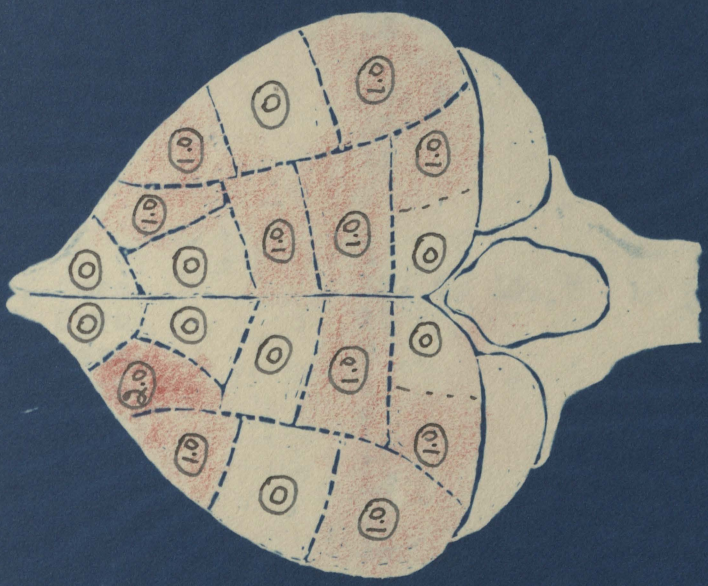

fig. 2

PLATE XXV

hemisphere. The general level of cortical disturbance, however, is low, quite homogeneous, with the suggestion of a posterior gradient. The average magnitude for all records under this condition is 1.10 as compared with .21 under room light and .35 under darkness.

Table XXXV.

Brain Position	Record Type	Average Magnitude
RIGHT HEMISPHERE		
Ant. fore.	8	2.0
Upper ant. med. fore.	1	0
Lower ant. med. fore.	13	1.0
Upper mid. med. fore.	13	1.0
Lower mid. med. fore.	13	1.0
Post. lft. med. fore.	13	1.0
Post. rt. med. fore.	9	2.0
Ant. lat. fore.	13, 8	1.5
Mid. lat. fore.	13	1.0
Post. lat. fore.	13	1.0
LEFT HEMISPHERE		
Ant. fore.	1	0
Upper ant. med. fore.	13, 8, 13, 7	1.5
Lower ant. med. fore.	13	1.0
Upper mid. med. fore.	8	2.0
Lower mid. med. fore.	1	0
Post. lft. med. fore.	8	2.0
Post. rt. med. fore.	13	1.0
Ant. lat. fore.	13	1.0
Mid. lat. fore.	12	1.0
Post. lat. fore.	13	1.0
	24 Records Average	1.10

(d). Animal Passive When Neck, Bill, or Back was Punched or Head Moved. In this situation the animal received definite tactual and kinaesthetic stimulation from head movement or by punching the neck, bill, or head. The animal remained passive. See Table XXXVI and Plate XXV, figure 2. A peak of medium amplitude occurs in the motor region of the left hemisphere, on

the lateral aspect. A large portion of the visual and association regions are slightly active, as well as the rest of the motor region. There is evidently a definite anterior-posterior gradient, which extends far around on the lateral side. The gross average magnitude, under this condition, was .55 as compared with .35 when the animal was passive in the dark.

Table XXXVI.

Brain Position	Record Type	Average Magnitude
RIGHT HEMISPHERE		
Ant. fore.	1	0
Upper ant. med. fore.	12	1.0
Lower ant. med. fore.	1	0
Upper mid. med. fore.	13	1.0
Lower mid. med. fore.	13	1.0
Post. lft. med. fore.	13	1.0
Post. rt. med. fore.	1	0
Ant. lat. fore.	13	1.0
Mid. lat. fore.	1, 1	0
Post. lat. fore.	1	0
LEFT HEMISPHERE		
ant. fore.	1	0
Upper ant. med. fore.	8	2.0
Lower ant. med. fore.	1	0
Upper mid. med. fore.	1	0
Lower mid. med. fore.	13	1.0
Post. lft. med. fore.	13	1.0
Post. rt. med. fore.	1	0
Ant. lat. fore.	13	1.0
Mid. lat. fore.	1	0
Post. lat. fore.	13	1.0
	21 Records	Average .55

(e). Winced or Wriggled Slightly When Punched Back or Neck or Tail. Under this situation the animal winced or wriggled slightly when its back or neck was punched, or its tail pulled, or its feathers stroked. See Table XXXVII and Plate XXVI, figure 1. The brain is almost homogeneously active at a medium

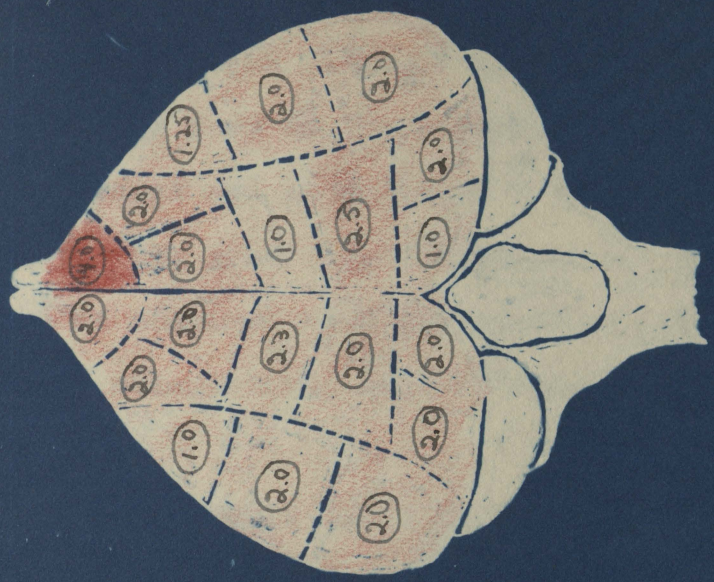

fig. 1

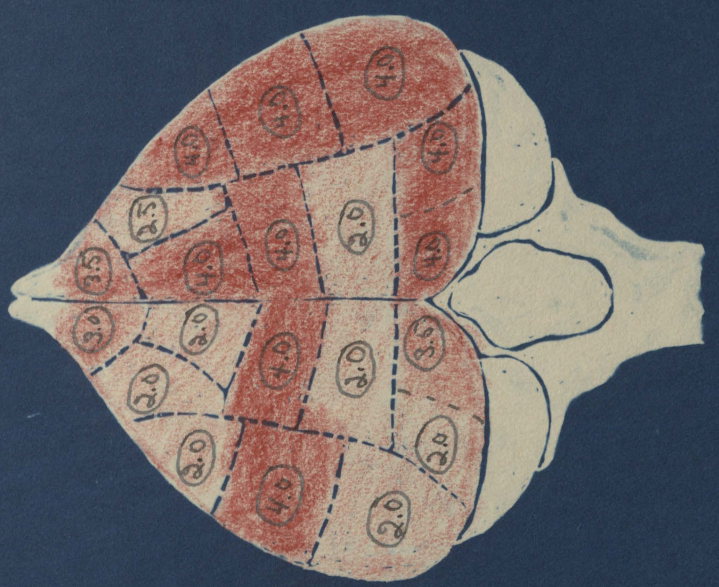

fig. 2

PLATE XXVI

level of amplitude. Of notable exception is the anterior portion of the right hemisphere which is ascribed a motor and olfactory function. The rest of the cortex, with the exception of a part of the visual and association region, shows a medium level of activity. The gross average magnitude, under this condition, was 1.95 as compared with .55 when the animal was passive under tactual stimulation, and .35 when the animal was passive in the dark.

Table XXXVII.

Brain Position	Record Type	Average Magnitude
RIGHT HEMISPHERE		
Ant. fore.	2	4.0
Upper ant. med. fore.	8	2.0
Lower ant. med. fore.	8	2.0
Upper mid. med. fore.	13	1.0
Lower mid. med. fore.	7+, 8	2.5
Post. lft. med. fore.	9	2.0
Post. rt. med. fore.	13	1.0
Ant. lat. fore.	13, 8-	1.25
Mid. lat. fore.	9	2.0
Post. lat. fore.	9	2.0
LEFT HEMISPHERE		
Ant. fore.	8	2.0
Upper ant. med. fore.	6, 8, 8	2.0
Lower ant. med. fore.	9	2.0
Upper mid. med. fore.	8, 8, 8+	2.3
Lower mid. med. fore.	8	2.0
Post. lft. med. fore.	6	2.0
Post. rt. med. fore.	8	2.0
Ant. lat. fore.	13	1.0
Mid. lat. fore.	9	2.0
Post. lat. fore.	8, 9	2.0
	27 Records	Average 1.95

(f). Animal Struggled, Wiggled and Swallowed When Punched Bill. The animal struggled, wiggled and swallowed when its bill was punched. See Table XXXVIII and Plate XXVI, figure 2.

The figure shows certain differences between the two hemispheres although both have a medial band of maximum amplitude. In the left hemisphere there are other peaks in the posterior medial visual cortex and in the olfactory-motor area, giving the gradient two poles and a high center area in the 'association' region. In the right hemisphere there is more maximum activity, concentrated in the posterior and lateral aspects of the hemisphere, along a medial band. These areas include all the visual, most of the association, and part of the motor regions. The gross average magnitude for all the records was 3.12 as compared with 1.95 when the animal winced and .55 when the animal was passive to tactual stimulation.

Table XXXVIII.

Brain Position	Record Type	Average Magnitude
RIGHT HEMISPHERE		
Ant. fore.	5, 9	3.5
Upper ant. med. fore.	9+, 8	2.5
Lower ant. med. fore.	2	4.0
Upper mid. med. fore.	4, 11	4.0
Lower mid. med. fore.	8	2.0
Post. lft. med. fore.	2	4.0
Post. rt. med. fore.	2	4.0
Ant. lat. fore.	11	4.0
Mid. lat. fore.	11	4.0
Post. lat. fore.	2	4.0
LEFT HEMISPHERE		
Ant. fore.	8+	3.0
Upper ant. med. fore.	8	2.0
Lower ant. med. fore.	9	2.0
Upper mid. med. fore.	11, 5	4.0
Lower mid. med. fore.	9	2.0
Post. lft. med. fore.	8	2.0
Post. rt. med. fore.	2, 8+	3.5
Ant. lat. fore.	7	2.0
Mid. lat. fore.	4	4.0
Post. lat. fore.	8	2.0
	25 Records	Average 3.12

(g). Animal Curled Feet and Wriggled When Feet Were Hit. In this situation the animal curled its feet and wriggled. See Table XXXIX and Plate XXVII, figure 1. In the left hemisphere the peaks are in the posterior lateral and anterior lateral aspects, which includes the association, and parts of the motor and visual regions. The gradient is definitely anterior-posterior in type. In the right hemisphere there is less maximum activity, but peaks appear in the anterior, posterior medial, and extreme lateral aspects of the hemisphere, in part of the olfactory, motor, association and visual regions. The average magnitude, under this condition, is 2.74 as compared with 3.12 when the animal's bill was punched and .55 when the animal was passive to tactual stimulation.

Table XXXIX.

Brain Position	Record Type	Average Magnitude
RIGHT HEMISPHERE		
Ant. fore.	2	4.0
Upper ant. med. fore.	8-	1.5
Lower ant. med. fore.	8	2.0
Upper mid. med. fore.	13	1.0
Lower mid. med. fore.	2, 8	3.0
Post. lft. med. fore.	8	2.0
Post. rt. med. fore.	3	4.0
Ant. lat. fore.	12	1.0
Mid. lat. fore.	4	4.0
Post. lat. fore.	8, 3, 8	2.6
LEFT HEMISPHERE		
Ant. fore.	11	4.0
Upper ant. med. fore.	4	4.0
Lower ant. med. fore.	2, 13	2.5
Upper mid. med. fore.	8-, 13	1.2
Lower mid. med. fore.	11	4.0
Post. lft. med. fore.	7	2.0
Post. rt. med. fore.	8	2.0
Ant. lat. fore.	7	2.0
Mid. lat. fore.	2	4.0
Post. lat. fore.	11	4.0
	25 Records Average	2.74

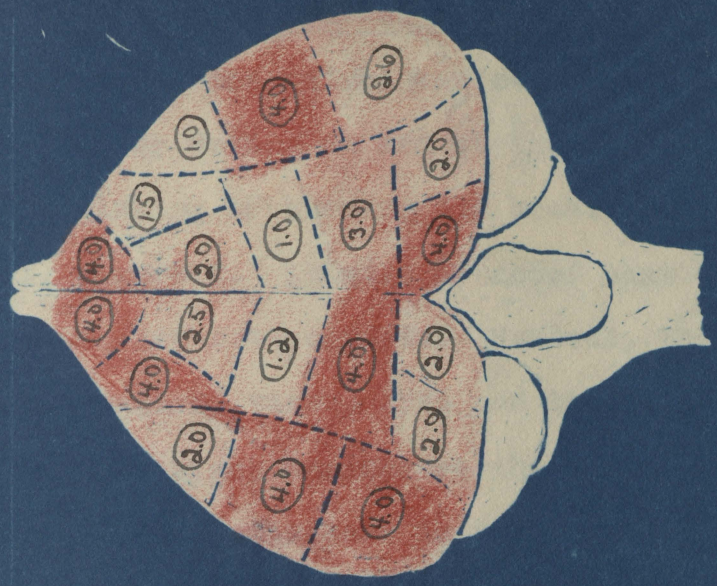

fig. 1

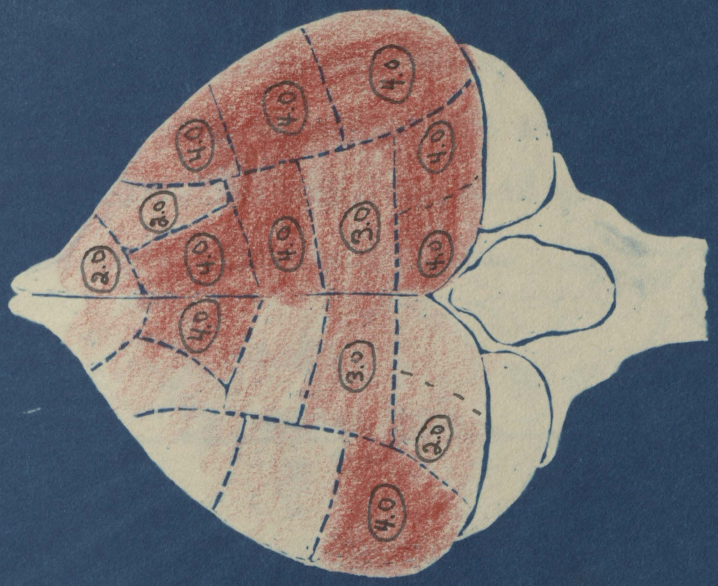

fig. 2

PLATE XXVII

(h). Animal Winked and Turned Head When Blew or Waved Arm. In this situation the animal was stimulated either by blowing at its head or waving an arm at the animal. The animal responded by winking or turning its head. See Table XL and Plate XXVII, figure 2. It will be noted that the data on the left hemisphere are not complete. However, they show two peaks, one in the lateral visual area and the other in the motor region. In the right hemisphere the entire lateral and posterior aspect of the hemisphere is maximum, including the visual and association regions. The medial association and motor regions are also maximum. The very anterior end of the hemisphere is only moderately active. The general trend of the gradient is posterior to medial and lateral. The average magnitude, under this condition, was 3.42 as compared with 3.12 when the animal's bill was punched.

Table XL

Brain Position	Record Type	Average Magnitude
RIGHT HEMISPHERE		
Ant. fore.	9	2.0
Upper ant. med. fore.	9	2.0
Lower ant. med. fore.	5	4.0
Upper mid. med. fore.	5	4.0
Lower mid. med. fore.	7+, 9+	3.0
Post. lft. med. fore.	4	4.0
Post. rt. med. fore.	5	4.0
Ant. lft. fore.	5	4.0
Mid. lat. fore.	5	4.0
Post. lat. fore.	5	4.0
LEFT HEMISPHERE		
Lower ant. med. fore.	4, 4	4.0
Lower mid. med. fore.	7+	3.0
Post. lft. med. fore.	6	2.0
Post. lat. fore.	4, 4	4.0
	17 Records	Average 3.42

(i). Animal Winked When Right or Left Eye Was Punched. Under this behavior situation the animal's right or left eye was punched with the rubber end of the pencil, to which the animal responded by blinking. See Table XLI and Plate XXVIII, figure 1. Both hemispheres are highly and fairly uniformly active under this condition. There is a definite tendency toward an anterior-posterior type of gradient, which is more pronounced in the right than in the left hemisphere. In the left hemisphere there is only a small anterior peak in the motor region that is maximum, while most of the posterior lateral regions are highly active. The gross average magnitude is 3.36.

Table XLI

Brain Position	Record Type	Average Magnitude
RIGHT HEMISPHERE		
Ant. fore.	11	4.0
Upper ant. med. fore.	5	4.0
Lower ant. med. fore.	3, 9+, 8	3.0
Upper mid. med. fore.	11, 6, 5	3.3
Lower mid. med. fore.	4, 3, 5	4.0
Post. lft. med. fore.	13, 3	2.5
Post. rt. med. fore.	9+, 3, 4,	3.6
Ant. lat. fore.	11, 11, 11	4.0
Mid. lat. fore.	9+, 9+, 4	3.3
Post. lat. fore.	10-, 3, 9	3.0
LEFT HEMISPHERE		
Ant. fore.	8, 8+	2.5
Upper ant. med. fore.	3, 3, 10, 5, 3, 3	4.0
Lower ant. med. fore.	3, 9	3.0
Upper mid. med. fore.	4, 4, 9+, 8+, 3	3.6
Lower mid. med. fore.	7+	3.0
Post. lft. med. fore.	10	4.0
Post. rt. med. fore.	9+, 8	2.5
Ant. lat. fore.	6	2.0
Mid. lat. fore.	5	4.0
Post. lat. fore.	4, 11	4.0
	48 Records Average	3.36

(j) Animal Wriggled, Struggled, or Moved Head Spontaneously.

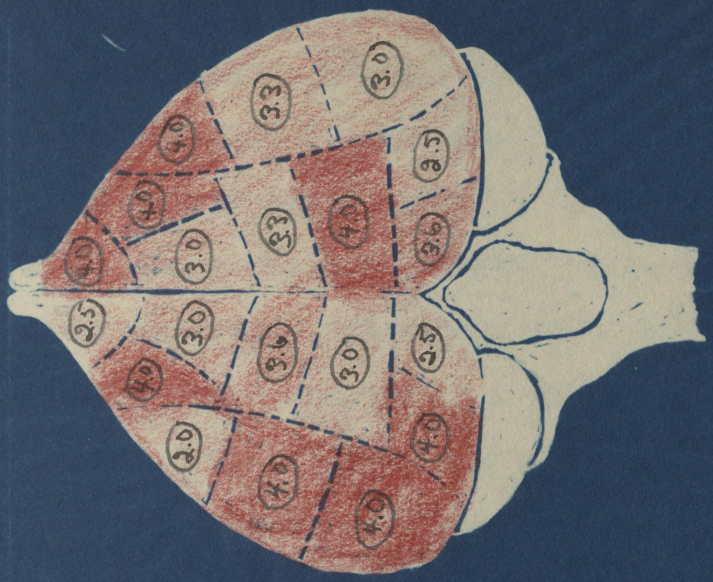

fig. 1

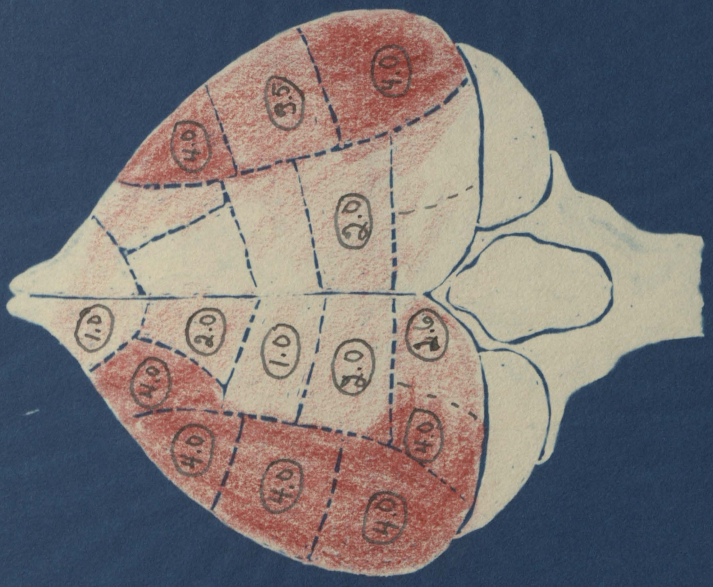

fig. 2

PLATE XXVIII

The animal was given no stimulation but moved head, wriggled, or struggled, spontaneously. See Table XLII and Plate XXVIII, figure 2. Although the data on the right hemisphere are incomplete there is a fairly close correlation between the two hemispheres. Both show a definite lateral gradient which extends, at a maximum amplitude, all along the lateral aspect of the hemispheres. The other regions in this case are moderately or slightly active. The regions that are maximum include part of the visual, association and motor areas. The gross magnitude of the records is 3.00

Table XLII

Brain Position	Record Type	Average Magnitude
RIGHT HEMISPHERE		
Lower mid. med. fore.	9	2.0
Ant. lat. fore.	3	4.0
Mid. lat. fore.	8, 11, 11, 4	3.5
Post. lat. fore.	4	4.0
LEFT HEMISPHERE		
Ant. fore.	13	1.0
Upper ant. med. fore.	11	4.0
Lower ant. med. fore.	8	2.0
Upper mid. med. fore.	13	1.0
Lower mid. med. fore.	8, 8	2.0
Post. lft. med. fore.	5	4.0
Post. rt. med. fore.	8, 11, 8	2.6
Ant. lat. fore.	5	4.0
Mid. lat. fore.	5	4.0
Post. lat. fore.	5	4.0
	20 Records Average	3.00

(k). Animal Passive With Quincke Tube, 325 Fork or High Siren. In this situation the animal was passive. See Table XLIII and Plate XXIV, figure 1. In both hemispheres there is a definite middle lateral gradient, in the association and part of the visual region. If a homologue be assumed between

the pigeon and higher animal forms this is roughly the auditory region. The level of magnitude is only medium or slightly above. In both hemispheres there is a slightly active middle medial band occuping the association region. For the most part the majority of the visual and motor regions are very slightly active or show no activity. The gross average magnitude, under this condition, was 1.00 as compared with .21 with the animal passive in the room light and 1.10 with flashlight stimulation.

Table XLIII

Brain Position	Record Type	Average Magnitude
RIGHT HEMISPHERE		
Ant. fore.	1	0
Upper ant. med. fore.	13	1.0
Lower ant. med. fore.	1	0
Upper mid. med. fore.	13	1.0
Lower mid. med. fore.	13	1.0
Post. lft. med. fore.	13	1.0
Post. rt. med. fore.	1	0
Ant. lat. fore.	13	1.0
Mid. lat. fore.	13, 8	1.5
Post. lat. fore.	9+	3.0
LEFT HEMISPHERE		
Ant. fore.	1	0
Upper ant. med. fore.	9, 13	1.5
Lower ant. med. fore.	1	0
Upper mid. med. fore.	1, 13	.5
Lower mid. med. fore.	8	2.0
Post. lft. med. fore.	13	1.0
Post. rt. med. fore.	1+	.5
Ant. lat. fore.	9	2.0
Mid. lat. fore.	8	2.0
Post. lat. fore.	13	1.0
	23 Records	Average 1.00

(1). Animal Jumped, Winced, or Blinked with Quincke Tube. In this situation a 1,024 d.v. quincke tube was blown. The animal responded by jumpting, wincing or blinking, See

Table XLIV and Plate XXIX, figure 2. The middle lateral gradient, found with the animal quiet under sound stimulation has shifted to the anterior olfactory and motor regions in the right hemisphere, and forward to the motor region in the left hemisphere, but it still remains largely lateral in character. The rest of the regions are almost homogeneously low, or a little better, in magnitude. It is significant that the

Table XLIV.

Brain Position	Record Type	Average Magnitude
RIGHT HEMISPHERE		
Ant. fore.	4	4.0
Upper ant. med. fore.	13, 8	1.5
Lower ant. med. fore.	13, 1	.5
Upper mid. med. fore.	13	1.0
Lower mid. med. fore.	13, 13	1.0
Post. lft. med. fore.	8	2.0
Post. rt. med. fore.	8, 8	2.0
Ant. lat. fore.	3, 9+, 1	2.3
Mid. lat. fore.	13	1.0
Post. lat. fore.	13, 8	1.5
LEFT HEMISPHERE		
Ant. fore.	1, 1	0
Upper ant. med. fore.	8	2.0
Lower ant. med. fore.	13	1.0
Upper mid. med. fore.	8-	1.5
Lower mid. med. fore.	12	1.0
Post. lft. med. fore.	13	1.0
Post. rt. med. fore.	13, 13	1.0
Ant. lat. fore.	5	4.0
Mid. lat. fore.	13	1.0
Post. lat. fore.	12	1.0
	29 Records Average	1.51

visual regions are slightly more active under this condition. Also significant is the fact that the peaks in this case are maximum in amplitude, while, with the animal passive, they were only medium in amplitude. The slightly active portions of the

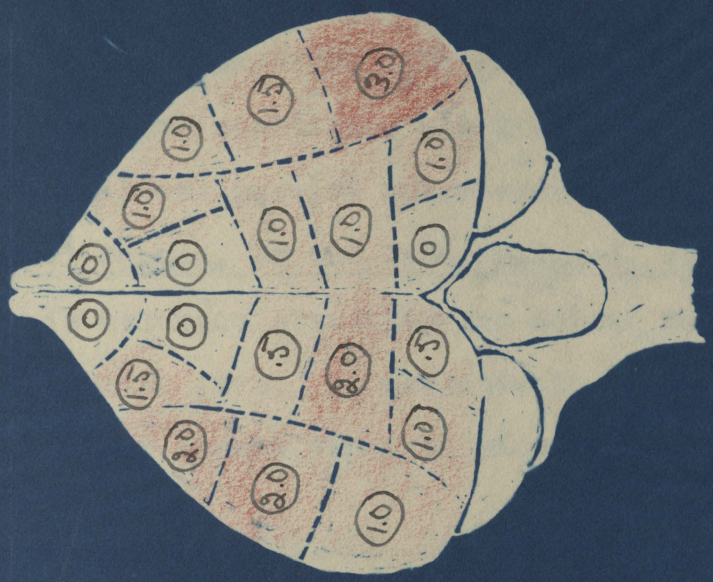

fig. 1

fig. 2

PLATE XXIX

brain, under this condition, take on more of a homogeneity than when the animal is passive. The gross average magnitude, under the present condition, was 1.51, as compared with 1.00 when the animal was passive under sound stimulation.

(m). Animal Jumped, Turned Head, Blinked, with 325 d.v. Fork. Under this behavior situation the animal was stimulated with a 325 d.v. tuning fork. In response it jumped, turned its head, blinked, or opened its eyes wider. See Table XLV

Table XLV.

Brain Position	Record Type	Average Magnitude
RIGHT HEMISPHERE		
Post. lft. med. fore.	13+	1.5
Ant. lat. fore.	8	2.0
LEFT HEMISPHERE		
Ant. fore.	8	2.0
Upper ant. med. fore.	3	4.0
Lower ant. med. fore.	8	2.0
Upper mid. med. fore.	8	2.0
Post. lft. med. fore.	9, 8, 8, 13	1.7
Post. rt. med. fore.	13	1.0
Ant. lat. fore.	8+	3.0
Mid. lat. fore.	9	2.0
Post. lat. fore.	7	2.0
	14 Records Average	2.10

and Plate XXX, figure 1. The right hemisphere is very incomplete, but the areas studies agree almost perfectly with the corresponding areas of the left hemisphere. In the left hemisphere there appears the same anterior-lateral gradient which was found when the animal was active to quincke tube stimulation. In this case the motor region is maximum. The homogeneous level of the rest of the hemisphere now rises to medium activity with slightly less action in the visual than in the

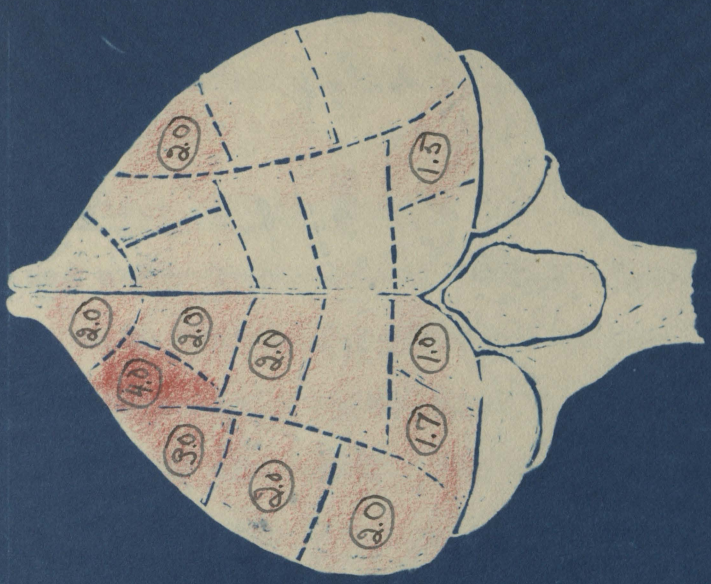

fig. 1

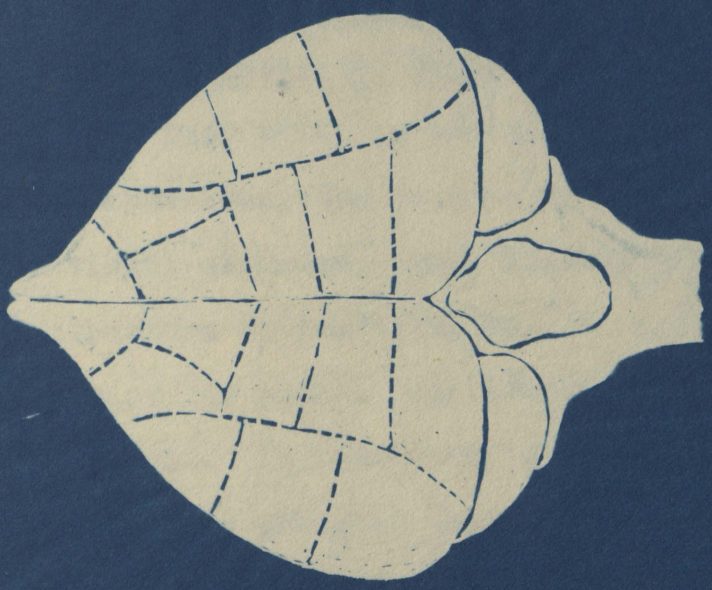

fig. 2

PLATE XXX

other regions. The gross average for this condition is 2.10 as compared with 1.51 when the animal was active with quincke tube stimulation.

(3). Conclusions on the Bird. - The data on the pigeon can be summarized under seven heads: light stimulation; tactual stimulation with the animal passive; tactual stimulation with the animal active; pain stimulation with the animal active; spontaneous activity of the animal; tactual-and-visual (blowing, waving arm) stimulation with the animal active; and auditory stimulation.

(a). Light Stimulation. In situation (b), darkness, the gradient has a definite posterior peak. This can probably be accounted for by the fact that, in the bird, with a highly structured visual apparatus, the absence of light proved, in reality to be a visual stimulus. That this is not, however, reasoning from structure to function, will be explained in a subsequent section of the paper. The average magnitude, under this condition, was .35. In situation (a), where the animal was passive in room light the gradient becomes medial and lateral, with less activity. The visual regions are negative, which may be either an indication of adaptation or that the activity was below the threshold of the amplifier. The average magnitude, under this condition, is only .21 as compared with .35 under darkness. In situation (c), where a definite visual stimulus was given the animal, a flashlight in its eyes, there again appears a posterior gradient in the visual region, but with indications of an anterior peak in the motor region. In this case

the average magnitude is 1.10 as compared with .21 under room light, and .35 with the animal in the dark. The average of the flashlight and room light situations gives .65 as compared with .35 when the animal was in the dark.

(b). Animal Passive With Tactual Stimulation. In the one situation in this group, (d), the animal remained passive while its neck, bill or back was punched, or its head was moved. A definite anterior-posterior gradient appears with medium peaks in the motor and visual regions. The average magnitude of this condition is .55 as compared with .65 under light stimulation and .35 with the animal passive in the dark.

(c). Animal Responding to Tactual Stimulation. The first behavior situation in this group, (e), was when the animal winced or wriggled slightly as its neck or back was punched, tail pulled, or feathers stroked. The gradient is almost homogeneous at a medium level of magnitude. There is, however, a definite anterior peak in the motor and olfactory region. The medial visual region and medial association region are only slightly active. The average magnitude was 1.95. In the next situation, (i), the animal winked when either the left or the right eye was punched with the pencil rubber. Under this condition the general level of activity for most of the brain was maximum with a type of anterior-posterior-lateral gradient. This gradient included most of the motor regions, but only part of the visual. There was maximum activity in all the lateral regions. This gradient is in some ways similar to that found in (e) except that the level is much higher. The average magnitude in this case was 3.36. The average of the two behavior situations of

this group gives 2.65 as compared with .55 when the animal was passive to tactual stimulation, and .35 when the animal was passive in the dark.

(d). Animal Responding to Pain Stimulation. In the first situation of this group, (f), the animal struggled, wriggled and swallowed when its bill was punched with the point of the pencil. The gradient in this case shows a medial middle band, in each hemisphere, in the association region. The rest of the gradient is posterior and definitely lateral in the right hemisphere, and posterior and somewhat lateral in the left. These regions are all maximum. The rest of the visual region in the left hemisphere and the rest of the motor are moderately active. The average magnitude is 3.12. In the second situation of this group, (g), the animal curled its feet and wriggled when its feet were hit with the pencil. The gradient is similar to that under situation (f) except that the left hemisphere is more active than the right. There is the same medial, middle band, with the posterior-lateral gradient. In this case, however, there is a definite anterior peak in the motor and olfactory region. Again, only part of the visual region is active. The average magnitude under this condition is 2.74. The average of the two situations in this group gives 2.93 as compared with 2.65 when the animal was active to tactual stimulation, and .55 when the animal was passive to tactual stimulation.

(e). Spontaneous Activity of the Animal. In this situation, (j) the animal wriggled, struggled, or moved its head spontaneously, with no definite experimental stimulus. The

gradients in this case are definitely lateral and slightly posterior, so that a part of the visual region is involved, as well as the association and part of the motor regions. The average magnitude, under this condition was 3.00 as compared with 2.93 under pain stimulation, 2.65, active to tactual stimulation, and .55, passive to tactual stimulation.

(f). Animal Active to Tactual-and-Visual Stimulation. This behavior situation, (h), includes blowing at the animal or waving the arm, to which the animal reacted by winking or turning its head. The gradient shows a definite posterior and lateral aspect, which includes, at a maximum level, all of the visual region. In addition, the gradient shows a middle medial peak which extends into the motor region, suggesting an anterior pole. All of the association regions are maximum. The average magnitude, in this situation, is 3.42 as compared with 2.93 under pain stimulation, 3.00 when the animal moved spontaneously, 2.65 when the animal responded to tactual stimulation, and .55 when the animal was passive to tactual stimulation.

(g). Auditory Stimulation. In the first situation of this group, (k), the animal was passive when a 1024 d.v. quincke tube, 325 d.v. tuning fork or high siren were sounded. The gradients show a definite middle lateral peak which is only medium, a curious fact, in the higher animals, this is the auditory region. A middle medial band in the association region in each hemisphere is slightly active. The visual and motor regions are very slightly active. The average magnitude, under this condition, was 1.00. In the next situation, (l), the animal re-

sponded to the sound stimulus by blinking, wincing or jumping when the 1024 d.v. quincke tube was blown. The gradient is fairly homogeneous, but with definite maximum peaks in the anterior motor regions. There is still a slight posterior and lateral gradient in the rest of the hemisphere. The visual regions are more active under this condition than with the animal passive, but the slightly active portions of the brain have taken on a more homogeneous character than with the animal passive to sound stimulation. The average magnitude is 1.51 as compared with 1.00 when the animal was passive. In the next situation, (m), the animal jumped, turned its head, blinked, or opened its eyes when the 325 d.v. tuning fork was sounded. The gradient is definitely anterior-lateral, with a definite maximum peak in the motor region. In this gradient the homogeneous level of the other regions rises to exceed the active response to the quincke tube. There is slightly less activity in the visual regions. The average magnitude is 2.10 as compared with 1.51 when the animal responded to the quincke tube and 1.00 when the animal was passive to sound stimulation. The average of the two situations, in which the animal responded to the sound, gives, 1.80 as compared with 1.95 when the animal was active to tactual stimulation, 2.93 when the animal was active to pain stimulation, and 1.10 when the animal received a definite visual stimulus. The average of all the sound conditions gives an average of 1.53 as compared with .65 for the visual situation, .35 for the animal passive in the dark, and .55 for the animal passive to tactual stimulation.

VII. THE MAMMAL.

(1). Description of Experiments and Records - Ten experiments were performed on the rat, in which 342 records were secured. Plate XXXI shows a diagram of the rat's brain with the arbitrary locations used for the electrodes. The circles again mark the exact electrode positions used throughout the experiment.

Rat T May 9, 1933, 8:00 p.m.

Description of Records:

Record 1: The animal struggled spontaneously near the first of the record. Electrode: lft. post. med. forebrain. The record shows a short, large series at the first which ranges up to 25 mm. in amplitude. This activity gradually subsides, but the record remains irregular throughout, with throws of 5 mm. At the end of the first third there is a very short series with throws of 9 mm. Shortly following this there is a single throw of 15 mm. Type 4 (4).

Record 2. Animal quiet. Electrode: lft. post. med. forebrain. The record is negative. Type 1 (0).

Record 3. Animal struggling spontaneously. Electrode: rt. post. med. forebrain. The first third of the record is negative. At the end of this section there begins an extended series of fast throws, which vary in amplitude. The largest throws are 13 mm. in amplitude averaging about 10 mm. The record is active to the end. Type 11 (4).

Record 4. Animal quiet, but heard noise in loud speaker during recording. Electrode: rt. post. med. forebrain. The record shows, throughout, single impulses which are monophasic in character and are about 9 mm. in amplitude. These occur at a separation of 5 mm. very regularly throughout the record. Shorter throws, diphasic, occurred from 5 to 7 mm. in height. Type 12 (1).

Record 5. Animal struggled spontaneously. Electrode: rt. post. med. forebrain. The record begins very active, up to 25 mm. in amplitude. This series reaches its height at the end of the first third of the record, subsides, and reaches a second maximum at the end of the second third. This second maximum subsides at the end of the record. Type 11 (4).

Record 6. Animal struggled vigorously after punched tail with

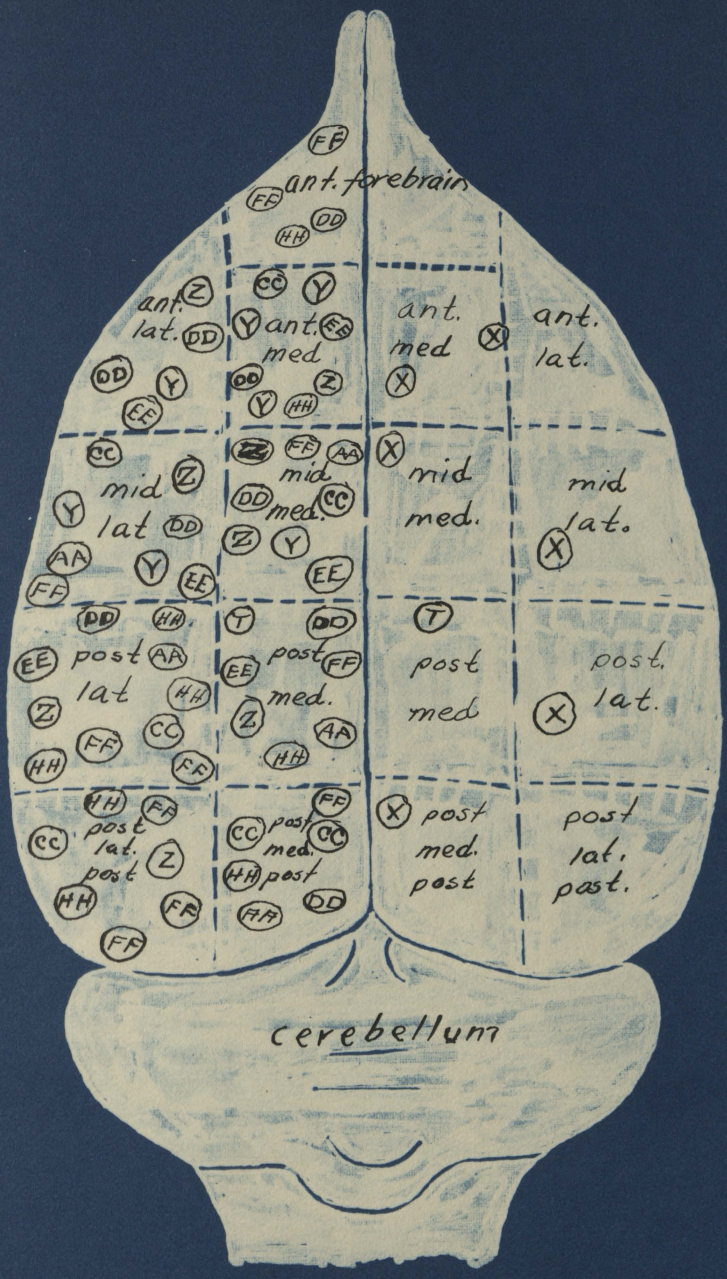
ant. forebrain
ant. lat.
ant. med
ant. med
ant. lat.
mid lat
mid med.
mid med.
mid lat.
post lat
post med.
post med
post lat.
post lat. post
post med. post
post med. post
post lat. past.
cerebellum

PLATE XXXI

pencil. Electrode: lft. post. med. forebrain. The record starts with an extended series which ranges up to 15 mm. These are fast throws which extend for more than the first half of the record. The last third of the record shows scattered throws of 5 mm. Type 11 (4).

Record 7. Closed circuit. The record is negative. Type 1 (0).

Record 8. Animal struggled spontaneously. Electrode: lft. post. med. forebrain. Record short, but shows beginning of a series of 15 mm. amplitude. Type 10 (4).

Rat X June 1, 1933, 9:00 p.m.

Description of Records:

Record 1. Animal quiet. Electrode: rt. mid. med. forebrain. The record is negative. Type 1 (0).

Record 2. Animal quiet. Electrode: rt. post. med. post. forebrain. The record is negative. Type 1 (0).

Record 3. Closed circuit. Record negative. Type 1 (0).

Record 4. Tapped head with pencil. Animal winced slightly. Electrode: rt. mid. med. forebrain. The record shows throws of 5 mm. scattered throughout. The appearance of the record is roughness. Type 13 (1).

Record 5. Tapped head twice with pencil. Animal winced slightly. Electrode: rt. post. med. post. forebrain. The record shows scattered throws of 5 mm. throughout. Type 13 (1).

Record 6. Hit foot with pencil twice. Animal passive. Electrode: rt. post. med. post. forebrain. The record is negative. Type 1 (0).

Record 7. Punched animal's back with pencil. Animal winced. Electrode: rt. mid. med. forebrain. The record shows scattered throws of 5 mm. throughout the record. Type 13 (1).

Record 8. Punched animal's back with pencil. Animal winced. Electrode: rt. post. med. post. forebrain. The record shows scattered throws of 5 mm. These form a series at the first of the record. Type 13 (1).

Record 9. Punched animal's back with pencil. Animal winced, stiffened and sniffed. Electrode: rt. post. med. post. forebrain. The first third of the record shows scattered throws of 5 mm. The rest of the record is a series of throws which ranges as high as 10 mm. in amplitude. Many of the throws seem to be monophasic. Type 10 (4).

Record 11. Punched animal's back three times. Winced, stiffened and sniffed. Electrode: rt. mid. med. forebrain. A

series of throws begins shortly after the record started. This series ranges up to 9 mm. in amplitude. The activity gradually subsides and then increases gradually to form the second series. Finally, a third series is formed near the end of the record. On the whole the total record is active, but there are gradations in amplitude. Type 11 (4).

Record 11. Pulled animal's tail. Winced and struggled slightly. Electrode: rt. mid. med. forebrain. The record shows activity throughout. This is of two types, toward the first of the record,--small 5 mm. throws in series and larger 9 mm. throws, singly. Toward the end of the record the larger size throws be come more numerous and form a fairly extended series. Type 10 (4).

Record 12. Pulled animal's tail. Animal winced and struggled. Electrode: rt. mid. med. forebrain. The record shows scattered throws of 5 mm. amplitude toward the first half of the record. The last half shows a long series which reached 15 mm. in amplitude. The throws are for the most part monophasic. Type 11 (4).

Record 13. Pulled animal's tail. Animal winced and struggled vigorously. Electrode: rt. post med. post. forebrain. The record is uniformly active throughout, with the throws all of the same type, ranging in amplitude from 10 mm. to 15 mm. Most of the throws are monophasic. Type 10 (4).

Record 14. Pulled tail. Animal winced and struggled slightly. Electrode: rt. post. med. post. forebrain. The first fourth of the record shows scattered throws of 5 mm. amplitude. From this point on the record shows throws singly and in series that range up to 9 mm. in amplitude. Type 5 (4).

Record 15. Punched animal's lft. eye with pencil. No response. Electrode: rt. post. med. post. forebrain. The record is quiet with the exception of a single throw of 10 mm. amplitude. Type 8 (2).

Record 16. Punched animal's lft. eye with pencil. No response. Electrode: rt. mid. med. forebrain. The record shows scattered throws of 5 mm. throughout. Type 13 (1).

Record 17. Animal quiet. Electrode: rt. mid. lat. forebrain. The record is negative. Type 1 (0).

Record 18. Animal quiet. Electrode: rt. ant. med. forebrain. The record is negative. Type 1 (0).

Record 19. Punched animal's lft. eye with pencil. No response. Electrode: rt. ant. med. forebrain. There are scattered throws of 5 mm. amplitude throughout record. Type 13 (1).

Record 20. Punched animal's lft eye with pencil. Shook whiskers. Electrode: rt. mid. lat. forebrain. The record shows scattered throws of 5 mm. amplitude, three of which appear as short series. Type 13 (1).

Record 21. Pulled animal's tail. Winced and struggled. Electrode: rt. mid. lat. forebrain. The beginning of the record shows small throws of 5 mm., but these soon increase in size up to 10 and 12 mm. The remainder of the record is active with a slight tapering off and scattering of activity toward the end of the record. The throws are fast in character. Type 11 (4).

Record 22. This record was taken after the electrode was removed by struggling, but is negative.

Record 23. Animal passive. Electrode: rt. post. lat. forebrain. Record is negative. Type 1 (0).

Record 24. Animal passive. Electrode: rt. ant. med. forebrain. The record is negative. Type 1 (0).

Record 25. Pulled animal's tail. Winced slightly. Electrode: rt. ant. med. forebrain. The record shows scattered throws of 5 mm. amplitude. Type 13 (1).

Record 26. Pulled animal's tail. Passive. Electrode: rt. post. lat. forebrain. The record is negative. Type 1 (0).

Record 27. Hit back of animal with pencil. Animal winced and sniffed. Electrode: rt. post. lat. forebrain. The record shows scattered throws of 5 and 6 mm. amplitude throughout. Type 13 (1).

Record 28. Hit back with pencil. Animal winced and struggled until finally removed electrode. Electrode: rt. post. lat. forebrain. The beginning of the record is quiet. Then there occurs a long series with throws which range up to 10 mm. in amplitude. About the middle of the record the electrode moved, but just before, there is a large series which ranges up to 40 mm. in amplitude. Type 4 (4).

Record 29. Animal had the 'jitters'--alternate bitting and chattering of teeth and quiet, in a rhythmic pattern. Had five 'jittering' attacks during record. Electrode: rt. post. lat. forebrain. The record shows five distinct series of throws all of which are about 30 mm. in length and range up to 15 mm. in amplitude. These are all very much alike and start gradually, increasing in amplitude to a maximum and then declining much in the same way in each case. Type 3 (4).

Record 30. Hit animal's back with pencil. Struggled slightly and 'whined'. Electrode: rt. ant. med. forebrain. The first part of the record is quiet, but toward the end a series begins which ranges up to 10 mm. in amplitude. Type 9 (2).

Rat Y June 2, 1933, 8:00 p.m.

Description of Records:

Record 1. Animal passive but breathing hard. Electrode: lft.

mid. med. forebrain. The record is negative. Type 1 (0).

Record 2. Animal passive. Electrode: lft. ant. med. forebrain. The record is negative. Type 1 (0).

Record 3. Closed. Record negative. Type 1 (0).

Record 4. Punched right eye with pencil. No response. Electrode: lft. mid. med. forebrain. The record is negative. Type 1 (0).

Record 5. Punched right eye. No response. Electrode: lft. ant. med. forebrain. The record is negative. Type 1 (0).

Record 6. Punched animal's back with pencil. Animal passive. Electrode: lft. ant. med. forebrain. The record is negative. Type 1 (0).

Record 7. Punched animal's back with pencil. Animal passive. Electrode: lft. mid. med. forebrain. The record is negative. Type 1 (0).

Record 8. Hit animal's nose with pencil. Animal winced slightly. Electrode: lft. mid. med. forebrain. The record shows short series of 5 and 6 mm. throws. Type 13 (1).

Record 9. Punched animal's back with pencil. Passive but changed breathing. Electrode: lft. ant. med. forebrain. Type 1 (0).

Record 10. Pulled animal's tail. Animal passive. Electrode: lft. mid. med. forebrain. The record is negative. Type 1 (0).

Record 11. Hit animal's back. Animal passive. Electrode: lft. ant. med. forebrain. The record is negative. Type 1 (0).

Record 12. Pulled animal's tail. Animal passive. Electrode: lft. ant. med. forebrain. The record is negative. Type 1 (0).

Record 13. Animal passive. Electrode: lft. ant. lat. forebrain. The record is negative. Type 1 (0).

Record 14. Animal passive. Electrode: lft. mid. lat. forebrain. The record is negative. Type 1 (0).

Record 15. Animal passive. Electrode: lft. mid. lat. forebrain. Pulled animal's tail. The record is negative. Type 1 (0).

Record 16. Pulled tail. Animal passive. Electrode: lft. ant. lat. forebrain. The record is negative. Type 1 (0).

Record 17. Sounded quincke tube into right ear. Animal passive. Electrode: lft. ant. lat. forebrain. The record is negative. Type 1 (o).

Record 18. Sounded quincke tube into right ear of animal.

Animal passive. Electrode: lft. mid. lat. forebrain. The record is negative. Type 1 (0).

Record 19. Pinched tail. Animal whined. Electrode: lft. mid. lat. forebrain. The record shows small activity in the latter half of the record with a short series of 8 mm. throws. Type 8 (2).

Record 20. Pinched tail. Animal winced and whined. Electrode: Lft. ant. lat. forebrain. The record is negative. Type 1 (0).

Record 21. Record lost.

Record 22. Animal passive. Electrode: lft. ant. med. forebrain. Record is negative. Type 1 (0).

Record 23. Animal passive. Electrode: lft. mid. lat. forebrain. The record is negative. Type 1 (0).

Record 24. Pinched animal's tail. Animal whined. Electrode: lft. mid. lat. forebrain. The record shows scattered throws of 5, 6, and 7 mm. amplitude. Type 13 (1).

Record 25. Pinched animal's tail. Animal whined. Electrode: lft. ant. med. forebrain. The record is negative. Type 1 (0).

Record 26. Punched animal's back with pencil. Animal passive. Electrode: lft. ant. med. forebrain. The record is negative. Type 1 (0).

Record 27. Punched animal's back with pencil. Animal wriggled. Electrode: lft. mid. lat. forebrain. The record shows scattered throws of 5 and 6 mm. amplitude. Type 13 (1).

Record 28. Punched animal's nose with pencil. Animal jumped and broke electrode. Electrode: lft. mid. lat. forebrain. The first two thirds of the record is quiet. In the last third there is a short series which reaches 40 mm. before the electrode moved. Type 2 (4).

Record 29. Punched animal's nose. Animal passive. Electrode: lft. ant. med. forebrain. The record is negative. Type 1 (0).

Record 30. Punched back. Animal whined. Electrode: lft. ant. med. forebrain. The record is negative. Type 1 (0).

Record 31. Punched animal's nose. Animal passive. Electrode: lft. ant. med. forebrain. The record is negative. Type 1 (0).

Record 32. Animal passive. Electrode: lft. ant. med. forebrain. The record is negative. Type 1 (0).

Record 33. Punched animal's nose. Animal winced. Electrode: lft. ant. med. forebrain. The first third of the record is quiet. Then there begins a short series which reaches an 8 mm.

amplitude. This is followed by another series of about the same size. At the beginning of the last third of the record there is a series which reaches 35 mm. This series is short, and abrupt in onset and termination. Type 2 (4).

Record 34. Pinched animal's tail. Animal passive. Electrode: lft. ant. med. forebrain. The record is negative. Type 1 (0).

Rat Z June 14, 1933, 2:30 p.m.

Description of Records:

Record 1. Closed circuit. The record is negative. Type 1 (0).

Record 2. Animal quiet, but breathering hard. Electrode: lft. post. med. forebrain. The record shows a short series of 6 mm. throws. Type 13 (1).

Record 3. Animal passive, but breathing hard. Electrode: lft. mid. med. forebrain. The record shows a short series of throws just after the center of the record, that reach 10 mm. in amplitude. Type 8 (2).

Record 4. Punched animal's right eye with pencil. Animal winced. Electrode: lft. mid. med. forebrain. The record shows 6 throws which are mostly monphasic, and, single throws of 11 mm. amplitude. There is one short series of throws at the end of the record. Type 8 (2).

Record 5. Punched animal's right eye with pencil. Animal passive. Electrode: lft. post. med. forebrain. The record is negative. Type 1 (0).

Record 6. Animal passive, but breathing hard. In the dark. Electrode: lft. post. med. forebrain. The record shows five short series scattered fairly evenly through the record, which reach 10 mm. amplitude. Type 8 (2).

Record 7. Animal passive in the dark. Electrode: lft. mid. med. forebrain. The record is negative. Type 1 (0).

Record 8. Shined flashlight into right eye. Animal passive. Electrode: lft. mid. med. forebrain. The record shows scattered small activity throughout, with a series of 10 mm. throws at the end. Type 8 (2).

Record 9. Shined flashlight into right eye of animal. Animal passive. Electrode: lft. post. med. forebrain. The record shows scattered throws of 5 and 6 mm. amplitude throughout. Type 13 (1).

Record 10. Sounded quincke tube into right ear of animal. Animal winced. Electrode: lft. post. med. forebrain. The record starts quietly but at the end of the first third shows a series

which reaches 13 mm. in amplitude. Type 8 (2).

Record 11. Sounded quincke tube into right ear of animal. Animal passive. Electrode: lft. mid. med. forebrain. The record is negative. Type 1 (0).

Record 12. Sounded 325 fork into right ear. Animal winced slightly. Electrode: lft. mid. med. forebrain. The record shows a short series which for one throw reaches a 10 mm. amplitude. Type 8 (2).

Record 13. Sounded 325 tuning fork into right ear. Animal passive. Electrode: lft. post. med. forebrain. The record is negative. Type 1 (0).

Record 14. Punched animal's back. Animal whined and winced. Electrode: lft. post. med. forebrain. The record shows a short series which reaches 10 mm. amplitude just after the center of the record. Type 8 (2).

Record 15. Punched animal's back. Animal passive. Electrode: lft. mid. med. forebrain. The record is negative. Type 1 (0).

Record 16. Pulled animal's tail. Animal passive. Electrode: lft. mid. med. forebrain. The record is negative. Type 1 (0).

Record 17. Pulled animal's tail. Animal winced and whined. Electrode: lft. post. med. forebrain. The record commences with a short series which reaches 10 mm. in amplitude. The remainder of the record is negative. Type 8 (2).

Record 18. Hit animal's body three times. Animal fairly passive. Electrode: lft. post. med. forebrain. The record shows scattered throws of 6 mm. amplitude, throughout. Type 13 (1).

Record 19. Hit animal's body three times. Animal passive. Electrode: lft. mid. med. forebrain. The record shows scattered throws of 5 mm. amplitude. Type 13 (1).

Record 20. Animal passive. Electrode: lft. mid. med. forebrain. The record is negative. Type 1 (0).

Record 21. Animal passive. Electrode: lft. mid. lat. forebrain. The record is negative. Type 1 (0).

Record 22. Punched animal's right eye with pencil. Animal jumped. Electrode: lft. mid. lat. forebrain. The record is negative. (1).

Record 23. Punched animal's right eye with pencil. Animal passive. Electrode: lft. mid. med. forebrain. The record is negative. Type 1 (0).

Record 24. Animal passive in the dark. Electrode: lft. mid.

med. forebrain. The record shows a short series at the end of the first third of the record, which reaches 10 mm. amplitude. Type 8 (2).

Record 25. Animal passive in the dark. Electrode: lft. mid. lat. forebrain. The record is negative. Type 1 (0).

Record 26. Shined flashlight into right eye of animal. Electrode: lft. mid. lat. forebrain. The record shows scattered throws of 5 mm. amplitude. Type 13 (1).

Record 27. Shined flashlight into right eye of animal. Animal passive. Electrode: lft. mid. med. forebrain. The record is negative. Type 1 (0).

Record 28. Hit animal's back twice with pencil. Animal struggled slightly. Electrode: lft. mid. med. forebrain. The record is negative. Type 1 (0).

Record 29. Hit animal's back with pencil twice. Animal struggled and removed electrode at end of record. Electrode: lft. mid. lat. forebrain. The record is quiet until the last of the record where there is a short series which reaches a 40 mm. amplitude before the electrode moved. Type 2 (4).

Record 30. Animal passive in the room light. A passing street car disturbed the record. Electrode: lft. ant. lat. forebrain. There is activity of 15 mm. amplitude which cannot be considered as from the animal. Type 1 (0).

Record 31. Animal passive. Electrode: lft. post. lat. post. forebrain. The record shows scattered throws of 5 mm. amplitude. Type 13 (1).

Record 32. Punched animal's right eye with pencil. Animal jumped and whined. Electrode: lft. post. lat. post. forebrain. The record shows scattered throws of 5 mm. throughout. Type 13 (1).

Record 33. Punched animal's right eye with pencil. Animal passive. Electrode: lft. ant. lat. forebrain. The record shows scattered throws of 5 mm. amplitude. Type 13 (1).

Record 34. Hit animal's back three times with pencil. Animal struggled. Electrode: lft. ant. lat. forebrain. The record shows a short series of 9 mm. amplitude throws, in the first third of the record. Type 8 (2).

Record 35. Hit animal's back three times with pencil. Animal struggled. Electrode: lft. post. lat. post. forebrain. The record is negative. Type 1 (0).

Record 36. Sounded quincke tube into right ear of animal. Animal winced. Electrode: lft. post. lat. post. forebrain. The record is negative. Type 1 (0).

Record 37. Sounded quincke tube into right ear of animal. Animal passive. Electrode: lft. ant. lat. forebrain. The record shows scattered throws of 6 and 7 mm. amplitude. Type 13 (1).

Record 38. Sounded 325 fork into right ear of animal. Animal passive. Electrode: lft. ant. lat. forebrain. The record shows scattered throws of 5 mm. amplitude. Type 13 (1).

Record 39. Sounded 325 tuning fork into right ear of animal. Animal passive. Electrode: lft. post. lat. post. forebrain. The record is negative. Type 1 (0).

Record 40. Pulled animal's tail. Animal struggled. Electrode: lft. post. lat. post. forebrain. The record is negative. Type 1 (0).

Record 41. Pulled animal's tail. Animal winced and struggled. Electrode: lft. ant. lat. forebrain. The record shows scattered throws of 6 mm. amplitude. Type 13 (1).

Record 42. Animal quiet. Electrode: lft. post. lat. forebrain. The record shows throws of 10 mm. amplitude, in short series. Type 8 (2).

Record 43. Animal quiet. Electrode: lft. ant. med. forebrain. The record shows a short series of 10 mm. throws at the end of the record. Type 8 (2).

Record 44. Punched animal's right eye. Animal jumped. Electrode: lft. ant. med. forebrain. The record shows large throws of 15 mm. amplitude occurring singly throughout the record. Type 8 (2).

Record 45. Punched right eye of animal. Animal passive. Electrode: lft. post. lat. forebrain. The record is negative. Type 1 (0).

Record 46. Sounded quincke tube into right ear of animal. Animal passive. Electrode: lft. post. lat. forebrain. The record is negative. Type 1 (0).

Record 47. Omitted.

Rat AA June 15, 1933, 9:00 p.m.

Description of Records:

Record 1. Animal passive. Electrode: lft. mid. med. forebrain. The record is negative. Type 1 (0).

Record 2. Animal passive. Electrode: lft. mid. lat. forebrain. The record is negative. Type 1 (0).

Record 3. Closed. The record is negative. Type 1 (0).

Record 4. Animal passive. Electrode: lft. post. med. post. forebrain. The record is negative. Type 1 (0).

Record 5. Animal passive. Electrode: lft. post. lat. forebrain. The record is negative. Type 1 (0).

Record 6. Animal passive. Electrode: lft. post. med. forebrain. The record is negative. Type 1 (0).

Record 7. Animal passive. Electrode: lft. mid. lat. forebrain. The record is negative. Type 1 (0).

Record 8. Animal passive. Electrode: lft. post. med. forebrain. The record is negative. Type 1 (0).

Record 9. Animal passive. Electrode: lft. mid. lat. forebrain. The record is negative. Type 1 (0).

Rat CC June 23, 1933, 9:00 p.m.

Description of Records:

Record 1. Closed circuit. The record is negative, except for two single throws of 15 mm. amplitude which are diphasic. Type 1 (0).

Record 2. Animal passive. Electrode: lft. post. med. post. forebrain. The record is negative. Type 1 (0).

Record 3. Animal passive. Electrode: lft. ant. med. forebrain. The record is negative. Type 1 (0).

Record 4. Sounded quincke tube into right ear of animal. Animal passive. Electrode: lft. ant. med. forebrain. The record is negative. Type 1 (0).

Record 5. Sounded quincke tube into right ear of animal. Animal winced slightly. Electrode: lft. post. med. post. forebrain. The record shows throws of 5 mm. amplitude, uniform throughout. Type 12 (1).

Record 6. Animal winced and breathed hard. (Passive?) Do not think got response on record. Electrode: lft. post. med. post. forebrain. The record is negative. Type 1 (0).

Record 7. Hit animal's back with pencil. Animal winced slightly. Electrode: lft. post. med. post. forebrain. The first half of the record is quiet. Just after the center of the record there occurs a short series which reaches 8 mm. in amplitude. Type 8 (2) minus.

Record 8. Hit animal's back with pencil. Animal winced and wriggled. Electrode: lft. ant. med. forebrain. The record shows small activity throughout with four series which reach

10 mm. in amplitude. These series are fairly short and are abrupt from the lower level activity. Type 9 (2).

Record 9. Punched animal's right eye with pencil. Animal blinked. Electrode: lft. ant. med. forebrain. The record shows scattered activity of 6 mm. throughout, with a series of 9 mm. throws about the center. Type 9 (2).

Record 10. Punched animal's right eye with pencil. Animal blinked. Electrode: lft. post. med. post. forebrain. The record shows two very short series which reached a 10 mm. amplitude. Type 8 (2) minus.

Record 11. Hit animal's back with pencil. Animal winced. Electrode: lft. post. med. post. forebrain. The record shows activity of 10 mm. amplitude scattered irregularly through the record with a fairly long series in the middle. Type 9 (2) plus.

Record 12. Hit animal's nose with pencil. Animal jumped slightly. Electrode: lft. post. med. post. forebrain. The first half of the record shows a series which reaches 10 mm. in several places, but is quite irregular. The last third of the record is quiet. Type 9 (2).

Record 13. Animal spontaneously winced and swallowed. Electrode: lft. post. lat. post. forebrain. Shows a series which reaches 10 mm. just after the start of the record. This gradually subsides and then there appears another series on the last half of the record. Type 9 (2).

Record 14. Animal spontaneously struggled and swallowed. Electrode: lft. ant. med. forebrain. The record begins with a long large series which reaches 20 mm. in amplitude and then irregularly tapers off to quiet at the end. Type 11 (4).

Record 15. Animal quiet exdept for licking chops and swallowing. Electrode: lft. post. lat. post. forebrain. The record shows 4 series of 10 mm. amplitude scattered in with smaller activity. Type 8 (2).

Record 16. Animal passive, but licking chops. Electrode: lft. ant. med. forebrain. The record shows throws of 5 mm. amplitude scattered throughout. Type 12 (1).

Record 17. Hit animal's back with pencil. Animal winced slightly. Electrode: lft. ant. med. forebrain. The record shows uniform activity of 6 mm. amplitude throughout. Type 12 (1).

Record 18. Hit animal's back with pencil. Animal jumped and winced. Electrode: lft. post. lat. post. forebrain. The record begins with small activity which increases into an irregular series reaching 14 mm. in amplitude. This continues to the middle of the record where a long series begins and continues to the end, at 8 mm. amplitude. Type 9 (2) plus.

Record 19. Punched animal'r right eye with pencil. Animal jumped, and blinked. Electrode: lft. post. lat. post. forebrain. The record shows irregular activity of 5 and 6 mm. throughout, in the form of an extended series. Type 13 (1).

Record 20. Punched animal's right eye with pencil. Animal winced, blinked and jumped. Electrode: lft. ant. med. forebrain. The record shows short series of 9 mm. amplitude regularly spaced at 20 mm. intervals throughout the record. Type 8 (2).

Record 21. Hit animal's back with pencil. Animal winced slightly. Electrode: lft. ant. med. forebrain. The record shows irregular activity which reaches 7 mm. amplitude, scattered throughout the record. Type 13 (1).

Record 22. Sounded quincke tube into right ear of animal. Animal blinked. Electrode: lft. ant. med. forebrain. The record shows scattered throws of 6 mm. amplitude throughout the record. Type 13 (1).

Record 23. Sounded quincke tube into right ear of animal. Animal passive. Electrode: lft. post. lat. post. forebrain. The record is negative. Type 1 (0).

Record 24. Omitted.

Record 25. Animal moving head and struggling spontaneously. Electrode: lft. mid. med. forebrain. The record is one continuous irregular series which reaches a maximum amplitude of 30 mm. The throws are fast, but irregular. Type 11 (4).

Record 26. Animal moving head and wincing spontaneously. Electrode: lft. mid. med. forebrain. The first half of the record shows a series which reaches 10 mm. In the last half there are two series which reach 13 mm. amplitude. Type 8 (2).

Record 27. Closed circuit. The record is not quiet but shows small activity scattered irregularly throughout. There are two spurious throws the full width of the film. Type 13 (1).

Record 28. Hit animal's back with pencil. Animal winced and whined. Electrode: lft. mid. med. forebrain. The record is negative until the very end where a series of 10 mm. throws appears. This series is fairly short. Type 8 (2).

Record 29. Animal moved head and swallowed spontaneously. Electrode: lft. mid. lat. forebrain. The record starts quietly, but there soon appears, gradually, a series which reaches 9 mm. in amplitude. In the center of the record there is a long series which gradually reaches 10 mm. and then tapers off. Type 9 (2).

Record 30. Hit animal's back with pencil. Animal whined. Electrode: lft. mid. med. forebrain. The record shows a series at the middle of the last half of the record, which reaches 9 mm.

amplitude. Type 8 (2).

Record 31. Sounded quincke tube into right ear of animal. Animal blinked, winced and wriggled. Electrode: lft. mid. med. forebrain. The record shows irregular activity of 5 mm. throughout, with four fast throws of 25 mm. amplitude scattered through the record. Type 2 (4).

Record 32. Sounded quincke tube into right ear of animal. Animal blinked and wriggled. Electrode: lft. mid. lat. forebrain. The record shows single, diphasic fast throws of 20 to 25 mm. amplitude, scattered through the record. These become more numerous at the end and form a short series. Type 2 (4).

Record 33. Animal wincing and swallowing spontaneously. Electrode: lft. post. med. post. forebrain. The first third of the record is negative. At the beginning of the second there is an abrupt series which reaches 20 mm. in amplitude. This series subsides and then ends abruptly with single throws of 16 mm. amplitude. Type 3 (4).

Record 34. Animal fairly quiet, but some swallowing. Electrode: lft. post. lat. forebrain. The first half of the record is fairly quiet. In the last half there are scattered throws of 20 mm. amplitude, with a short series at the end. Type 2 (4).

Record 35. Hit animal's back with pencil. Animal wriggled and struggled. Electrode: lft. post. lat. forebrain. The record shows scattered throws of 20 mm. amplitude throughout the record. In two places several of these throws go together to form a series. Type 2 (4).

Record 36. Hit animal's back three times with pencil. Wriggled and struggled slightly each time. Electrode: lft. post. med. post. forebrain. The record shows a short series of 10 mm. throws just after the record started. Then the record is quiet until just after the center when a series, very abrupt, in onset and termination occurs, which reaches 25 mm. amplitude. This is followed by a third, a longer series, which reaches 30 mm. in amplitude. The last fifth of the record is quiet. Type 4 (4).

Record 37. Hit animal's right eye with pencil. Animal blinked and jumped. Electrode: lft. post. med. post. forebrain. The first half of the record shows two small series of 8 mm. amplitude. In the last third of the record there are two series, very abrupt, which reach 15 and 20 mm. amplitudes, respectively. The last series occurs just before the end of the record. Type 4 (4).

Record 38. Hit animal's right eye with pencil. Animal jumped and blinked. Electrode: lft. post. lat. forebrain. The record shows a series of short duration which abruptly reaches 20 mm. amplitude. Type 2 (4).

Rat DD June 24, 1933, 9:30 p.m.

Description of Records:

Record 1. Animal quiet in room light. Electrode: lft. post. med. forebrain. The record shows irregular throws of 5 and 6 mm. amplitude. Type 13 (1).

Record 2. Animal passive in the room light. Electrode: lft. ant. lat. forebrain. The record shows irregular activity of 7 and 8 mm. throughout the record. Type 13 (1).

Record 3. Closed circuit. The record is quiet except for one spurious throw. Type 1 (0).

Record 4. Punched animal's right eye with pencil. Animal blinked. Electrode: lft. posterior median forebrain. The record shows irregular activity throughout, with a short series of 8 mm. throws in the center. Type 8 (2).

Record 5. Punched animal's right eye with pencil. Animal blinked. Electrode: left ant. lat. forebrain. The record shows irregular activity throughout, of 5 and 6 mm. Type 13 (1).

Record 6. Sounded quincke tube into right ear of animal. Animal shook whiskers. Electrode: lft. ant. lat. forebrain. The record shows uniform small activity of 6 and 7 mm. amplitude. Type 12 (1).

Record 7. Sounded quincke tube into right ear of animal. Animal shook whiskers. Electrode: left post. med. forebrain. The record shows uniform small activity of 7 and 8 mm. amplitude. Type 12 (1).

Record 8. Hit animal's back with pencil. Animal whined and struggled. Electrode: lft. posterior median forebrain. The record shows a long series at the level of 10 mm. Type 9 (2) plus.

Record 9. Hit animal's back with pencil. Animal wriggled slightly. Electrode: lft. ant. lat. forebrain. The record is negative. Type 1 (0).

Record 10. Hit animal's back with pencil. Animal wriggled and struggled. Electrode: lft. ant. lat. forebrain. The record shows irregular activity of 5 and 6 mm. amplitude. Type 13 (1).

Record 11. Animal passive in room light. Electrode: lft. mid. med. forebrain. The record shows irregular small activity of 6 and 7 mm. amplitude. Type 13 (1).

Record 12. Animal passive in the room light. Electrode: left mid. lat. forebrain. The record shows irregular small activity of 7 and 8 mm. amplitude. Type 13 (1).

Record 13. Punched animal's right eye with pencil. Animal blinked. Electrode: lft. mid. lat. forebrain. The record starts with activity which gradually increases abruptly to 20 mm. and then tapers off abruptly. Type 5 (4).

Record 14. Punched animal's right eye with pencil. Animal blinked and jumped slightly. Electrode: left mid. med. forebrain. The record shows irregular throws forming a series in the latter half of the record at the 8 mm. level of amplitude. Type 9 (2).

Record 15. Sounded quincke tube into right ear of animal. Animal passive. Electrode: left mid. med. forebrain. The record is negative. Type 1 (0).

Record 16. Sounded quincke tube into right ear of animal. Animal shook whiskers. Electrode: lft. mid. lat. forebrain. The record shows a fairly long series of 8 mm. throws. Type 9 (2).

Record 17. Hit animal's back with pencil. Animal wriggled. Electrode: left mid. lat. forebrain. The record shows irregular activity of 6 and 7 mm. amplitude throughout. Type 13 (1).

Record 18. Hit animal's back with pencil. Animal wriggled. Electrode: left. mid. med. forebrain. The record shows a fairly long series of 8 mm. amplitude. Type 9 (2).

Record 19. Hit animal's back with pencil. Animal whined. Electrode: left mid. med. forebrain. The record shows scattered activity of 5 and 6 mm. throughout. Type 13 (1).

Record 20. Animal passive in the room light. Electrode: lft. post. lat. forebrain. The record is negative. Type 1 (0).

Record 21. Animal passive in the room light. Electrode: lft. mid. lat. forebrain. The record is negative. Type 1 (0).

Record 22. Punched animal's right eye. Animal blinked and jumped. Electrode: left mid. lat. forebrain. The record shows a fairly long series which reaches 8 mm. in amplitude. Type 9 (2).

Record 23. Punched animal's right eye with pencil. Animal blinked and jumped. Electrode: left post. lat. forebrain. The record shows two fiarly long series, one in the first half and one in the last half of the record, which reach 10 mm. in amplitude. Type 9 (2).

Record 24. Sounded quincke tube into right ear of animal. Animal passive. Electrode: lft. post. lat. forebrain. The record shows uniform small activity of 5 and 6 mm. amplitude. Type 12 (1).

Record 25. Sounded quincke tube in right ear of animal. Ani-

mal passive. Electrode: lft. mid. lat. forebrain. The record shows uniform throws of 5 and 6 mm. amplitude. Type 12 (1).

Record 26. Hit animal's back with pencil. Animal wriggled and whined. Electrode: left mid. lat. forebrain. The record shows irregular activity of 6 and 7 mm. amplitude. Type 13 (1).

Record 27. Hit animal's back with pencil. Animal wriggled, whined and struggled. Electrode: left post. lat. forebrain. The record shows extended activity which reaches 16 mm. in amplitude. The record is irregular. Type 11 (4).

Record 28. Hit animal's back with pencil. Animal wriggled and whined. Electrode: left post. lat. forebrain. The record shows a fairly long series which reaches 10 mm. in amplitude. Type 9 (2).

Record 29. Animal passive in the room light. Electrode: lft. ant. med. forebrain. The record is negative. Type 1 (0).

Record 30. Animal passive in the room light. Electrode: lft. ant. forebrain. The record is negative. Type 1 (0).

Record 31. Hit animal's right eye with pencil. Animal blinked and jumped. Electrode: lft. ant. forebrain. The record shows regular throws of 6 and 7 mm. throughout. Type 12 (1).

Record 32. Hit animal's right eye with pencil. Animal blinked and jumped. Electrode: lft. ant. med. forebrain. The record shows irregular activity of 6 and 7 mm. amplitude throughout the record. Type 13 (1).

Record 33. Sounded quincke tube into right ear of animal. Animal wriggled whiskers. Electrode: lft. ant. med. forebrain. The record shows irregular activity of 6 and 7 mm. amplitude. Type 13 (1).

Record 34. Sounded quincke tube into right ear of animal. Animal stiffened slightly. Electrode: lft. ant. forebrain. The record shows two short series which reach 8 and 9 mm. amplitude. Type 8 (2).

Record 35. Hit animal's back with pencil. Animal whined and wriggled. Electrode: lft. ant. forebrain. There are two short series in the record which reach 9 mm. in amplitude. Type 8 (2).

Record 36. Hit animal's back with pencil. Animal whined and wriggled. Electrode: lft. ant. med. forebrain. The record shows one short series which reaches 9 mm. in amplitude. Type 8 (2).

Record 37. Hit animal's back with pencil. Animal whined and struggled vigorously. Electrode: lft. ant. med. forebrain. The record shows irregular extended activity which reaches an

amplitude of 35 mm. Type 11 (4).

Record 38. Animal quiet in room light. Electrode: lft. post. med. post. forebrain. The record shows irregular activity of 6 and 7 mm. amplitude. Type 13 (1).

Record 39. Animal fairly quiet, but licking chops. Electrode: lft. ant. lat. forebrain. The record shows two fairly long series which are 10 mm. in amplitude. Type 9 (2).

Record 40. Hit animal's right eye with pencil. Animal blinked. Electrode: lft. ant. lat. forebrain. The record commences with a fairly long series which reaches 10 mm. in amplitude. In the last third of the record there is another series which reaches 10 mm. Type 9 (2).

Record 41. Hit animal's right eye with pencil. Animal blinked. Electrode: lft. post. med. post. forebrain. The record shows two short series which reach 10 mm. in amplitude. Type 8 (2).

Record 42. Hit animal's back with pencil. Animal wriggled. Electrode: left post. med. post. forebrain. The record shows two fairly long series which reach 9 mm. in amplitude. Type 9 (2).

Record 43. Hit animal's back with pencil. Animal wriggled. Electrode: lft. ant. lat. forebrain. The record shows a fairly long series which reaches 9 mm. in amplitude. Type 9 (2).

Record 44. Sounded quincke tube into right ear of animal. Animal shook whiskers. Electrode: lft. ant. lat. forebrain. The record shows irregular activity of 5 and 6 mm. amplitude. Type 13 (1).

Record 45. Sounded quincke tube into right ear of animal. Animal shook whiskers. Electrode: lft. post. med. post. forebrain. The record shows a long series of 9 mm. amplitude. Type 7 (2).

Rat EE June 26, 1933, 9:00 p.m.

Description of Records: Record 1. Closed circuit. The record shows some A.C. but is fairly quiet. Type 1 (0).

Record 2. Animal quiet in room light. Electrode: lft. mid. med. forebrain. The record is irregular with throws of 5 and 6 mm. except for one spurious throw of 20 mm. Type 13 (1).

Record 3. Animal quiet in room light. Electrode: lft. mid. lat. forebrain. The record shows activity of 7 and 8 mm. throughout the record. Type 12 (1).

Record 4. Hit animal's right eye with pencil. Animal blinked. Electrode: lft. mid. lat. forebrain. The record shows a fair-

ly long irregular series which reaches 20 mm., abruptly, from small activity. This series continues until the last fourth of the record. Type 5 (4).

Record 5. Hit animal's right eye with pencil. Animal blinked. Electrode: lft. mid. med. forebrain. The record shows several short series which reach 10 mm. in amplitude. Type 8 (2).

Record 6. Hit animal's right eye with pencil. Animal blinked. Electrode: lft. mid. med. forebrain. The record shows a fairly long series just after the record started with reaches 21 mm. in amplitude and then tapers off irregularly. The last half of the record shows short series of 10 mm. amplitude. Type 5 (4).

Record 7. Sounded quincke tube into right ear of animal. Animal shook whiskers. Electrode: lft. mid. med. forebrain. The first half of the record is fairly quiet. In the last half there is a long series of 10 mm. throws, which is irregular. Type 9 (2).

Record 8. Sounded quincke tube into right ear of animal. Animal shook whiskers. Electrode: lft. mid. lat. forebrain. The record shows activity of 7 and 8 mm. amplitude throughout. The record is fairly regular. Type 12 (1).

Record 9. Hit animal's back with pencil. Animal winced. Electrode: left. mid. lat. forebrain. The record shows two long series of 10 mm. amplitude. One in the first of the record and one in the last half. Type 9 (2).

Record 10. Hit animal's back with pencil. Animal struggled and moved electrode. Electrode: lft. mid. med. forebrain. The first third of the record shows 8 short series which reach 60 mm. in amplitude and may be the movement of the electrode. In the last two thirds of the record there are short series which reach 20 mm. in amplitude. Type 4 (4).

Record 11. Hit animal's back with pencil. Animal wriggled. Electrode: lft. mid. med. forebrain. There is a fairly long series on the middle of the record which reaches 16 mm. in amplitude. This series is irregular. Type 11 (4).

Record 12. Animal passive in the room light. Electrode: lft. post. med. forebrain. The record shows irregular throws of 7 and 8 mm. amplitude. Type 13 (1).

Record 13. Animal passive in the room light. Electrode: lft. ant. lat. forebrain. The record shows irregular activity of 5 and 6 mm. amplitude. Type 13 (1).

Record 14. Punched animal's right eye with pencil. Animal blinked. Electrode: lft. ant. lat. forebrain. The record

shows a short series at the end of the first third of the record, which reaches 11 mm. in amplitude. The rest of the record is very quiet. Type 8 (2).

Record 15. Punched right eye of animal with pencil. Animal blinked. Electrode: lft. post. med. forebrain. Shows a short series which reaches 20 mm. in amplitude at the first of the record. There is another 20 mm. series at the beginning of the last third. The rest of the record shows medium activity, scattered. Type 2 (4).

Record 16. Sounded quincke tube into right ear of animal. Animal wriggled whiskers. Electrode: left post. med. forebrain. The record shows regular small 6 and 7 mm. throws throughout the record. There is one spurious throw of 15 mm. in the last fifth of the record. Type 12 (1).

Record 17. Sounded quincke tube into right ear of animal. Animal wriggled whiskers. Electrode: lft. ant. lat. forebrain. The record shows two very short series which reach 10 mm. in amplitude. The rest of the record is very quiet. Type 8 (2).

Record 18. Hit animal's back with pencil. Animal winced. Electrode: left ant. lat. forebrain. The record shows irregular small activity of 5, 6 and 7 mm. Type 13 (1).

Record 19. Hit animal's back with pencil. Animal winced and wriggled. Electrode: lft. post. med. forebrain. The record shows irregular small throws of 6 and 7 mm. throughout. Type 13 (1).

Record 20. Pulled animal's tail. Animal struggled. Electrode: left post. med. forebrain. The record shows a short series which reaches 30 mm. just after the record started. The rest of the record shows small activity. Type 2 (4).

Record 21. Omitted.

Record 22. Animal passive in the room light. Electrode: lft. ant. med. forebrain. The record shows irregular activity of 6 and 7 mm. amplitude. Type 13 (1).

Record 23. Animal passive in the room light. Electrode: lft. post. lat. forebrain. The record shows several short series which reach 10 mm. in amplitude. Type 8 (2).

Record 24. Hit animal's back with pencil. Animal winced and struggled. Electrode: lft. post. lat. forebrain. The record shows two long series which reach 10 mm. in amplitude. Type 9 (2).

Record 25. Hit animal's back with pencil. Animal winced and struggled. Electrode: lft. ant. med. forebrain. The first third of the record is quiet. At the beginning of the second

third there is an abrupt series which reaches 50 mm. in amplitude. This series is not very long and is followed by short series of 20 mm. amplitude. Type 4 (4).

Record 26. Hit animal's right eye with pencil. Animal blinked. Electrode: lft. ant. med. forebrain. The first half of the record shows an irregular series of 15 mm. throws. In the last third there is an irregular series which reaches 20 mm. Type 11 (4).

Record 27. Hit animal's right eye with pencil. Animal blinked. Electrode: lft. post. lat. forebrain. The record shows a very long series of regular throws which reaches 10 mm. in amplitude. Type 7 (2).

Record 28. Pulled animal's tail. Animal struggled and moved electrode. Electrode: lft. post. lat. forebrain. The record shows small activity in very large and short series superimposed by throws that reach 50 mm. Some of these throws are due to electrode movement. Type 2 (4).

Record 29. Pulled tail of animal. Animal winced. Electrode: left ant. med. forebrain. The record is negative. Type 1 (0).

(Note: Fifth stage of amplifier added. This fact is taken into account in classifying the records. This continues through rat FF).

Record 30. Animal passive in the room light. Electrode: lft. mid. med. forebrain. The record is highly and irregularly active, throughout. The throws are monophasic. The amplitude in the last half is 20 mm. Type 11 (4).

Record 31. Animal passive in the room light. Electrode: lft. mid. lat. forebrain. The record shows a fairly long series of 10 mm. throws. Type 9 (2).

Record 32. Hit animal's right eye with pencil. Animal blinked. Electrode: lft. mid. lat. forebrain. The record shows extended irregular activity which reaches 16 mm. in amplitude. Type 11 (4).

Record 33. Hit animal's right eye with pencil. Animal blinked. Electrode: lft. mid. med. forebrain. There is a short series just after the record started which reaches 25 mm. in amplitude. At the beginning of the last half of the record there is a longer series which reaches 23 mm. in amplitude. Type 5 (4).

Record 34. Hit animal's back with pencil. Animal struggled vigorously. Electrode: lft. mid. med. forebrain. The record starts fairly quietly but gradually forms a series which reaches 25 mm. in amplitude. Following this there is a series which reaches 40 mm. in amplitude. The last half of the record

shows uniform activity of 15 mm. amplitude. Type 5 (4).

Record 35. Hit animal's back with pencil. Animal winced and struggled. Moved electrode at very end of record. Electrode: lft. mid. lat. forebrain. The record starts with a short series which reaches 20 mm. in amplitude. At the beginning of the second half of the record more extended activity begins which reaches 30 mm. in amplitude. Type 11 (4).

Record 36. Sounded quincke tube into right ear of animal. Animal wriggled whiskers. Electrode: lft. mid. lat. forebrain. The first fourth of the record shows scattered small throws. At the beginning of the next section there is a series which reaches 45 mm. in amplitude. The last half of the record shows small scattered activity. Type 5 (4).

Record 37. Sounded quincke tube into right ear of animal. Animal wriggled whiskers. Electrode: lft. mid. med. forebrain. There is a fairly long series in the first half of the record which reaches 19 mm. in amplitude. This series is irregular. Type 5 (4).

Record 38. Pulled animal's tail. Animal winced. Electrode: lft. mid. med. forebrain. The first half of the record is fairly quiet. In the last half there is one short series which reaches 35 mm. in amplitude. Following this there is a longer series which reaches 45 mm. in amplitude. This latter series lasts irregularly to the end of the series. Type 5 (4).

Record 39. Pulled animal's tail. Animal struggled violently and finally moved electrode. Electrode: left mid. lat. forebrain. The record shows tended activity which is irregular in character. The throws reach 50 mm. in amplitude. Type 11 (4).

Record 40. Closed circuit. The record is highly active but irregular. The throws reach 30 mm. in amplitude. Type 11 (4).

Record 41. Animal passive in the room light. Electrode: lft. post. med. forebrain. The record is fairly quiet with a few scattered throws of 6 mm. amplitude in the middle of the record. Type 13 (1).

Record 42. Animal passive in the room light. Electrode: lft. ant. lat. forebrain. In the center of the record there is a short series of 14 mm. throws. Type 8 (2).

Record 43. Hit animal's right eye with pencil. Animal blinked. Electrode: lft. ant. lat. forebrain. The record shows extended activity which reaches 35 mm. in amplitude. The record is very irregular. Type 11 (4).

Record 44. Hit right eye with pencil. blinked, twice. Electrode: lft. post. med. forebrain. The record is regular and small throughout with throws of 5 and 6 mm. amplitude. Type 12 (1).

Record 45. Sounded quincke tube into right ear of animal. Animal wriggled whiskers. Electrode: lft. post. med. forebrain. The record shows two short series which arise abruptly from small activity and reach 25 mm. Type 2 (4).

Record 46. Sounded quincke tube into right ear of animal. Animal wiggled whiskers. Electrode: lft. ant. lat. forebrain. The record is negative. Type 1 (0).

Record 47. Hit animal's back with pencil. Animal winced. Electrode: lft. ant. lat. forebrain. The first 30 mm. of the record are quiet. At this point there commences extended activity which reaches 45 mm. in amplitude. The record is very irregular. Type 11 (4).

Record 48. Hit animal's back with pencil. Animal struggled. Electrode: lft. post. med. forebrain. The record came late. There is a short series which reaches 9 mm. in amplitude. Type 9 (2).

Record 49. Pulled animal's tail. Animal winced and wriggled. Electrode: lft. post. med. forebrain. There is a short series at the first of the record which reaches 16 mm. in amplitude. Type 4 (4).

Record 50. Pulled animal's tail. Animal winced and wriggled. Electrode: lft. ant. lat. forebrain. The record shows uniform small activity throughout of 7 and 8 mm. amplitude. Type 12 (1).

Rat FF June 28, 1933, 8:15, 9:45 p.m.

Description of Records:

Record 1. Closed circuit. The record is fairly quiet but fuzzy. Type 1 (0).

Record 2. Animal fairly passive in the room light. Licking chops. Electrode: lft. mid. med. forebrain. The record shows two series which reach 30 mm. in amplitude. These are very fast and separate. A negative section of the record in the center. Type 9 (2).

Record 3. Animal passive but licking chops in the room light. Electrode: lft. ant. forebrain. The record is irregular and shows throws of 40 mm.;there is extended activity throughout the record. Type 11 (4).

Record 4. Punched animal's right eye. Animal blinked. Electrode: lft. mid. med. forebrain. The record shows extended activity throughout which is very irregular. Type 11 (4).

Record 5. Punched animal's right eye with pencil. Animal blinked. Electrode: lft. ant. forebrain. The record shows several short series which reach 25 mm. in amplitude. These

series are fairly gradual. Type 4 (4).

Record 6. Hit animal's back with pencil. Animal winced and whined. Electrode: lft. mid. med. forebrain. The first 60 mm. of this record are quiet. At this point there occurs a fairly abrupt series which reaches 25 mm. in amplitude. Shortly following this series there is a longer series which also reaches 25 mm. in amplitude and tapers off gradually to the end of the record. Type 5 (4).

Record 7. Hit animal's back with pencil. Animal whined and winced. Electrode: lft. anterior forebrain. The first half of the record shows scattered small activity. At the beginning of the second half there is a fairly long series which reaches 20 mm. and is irregular. Type 5 (4).

Record 8. Sounded quincke tube into right ear of animal. Animal passive. Electrode: lft. ant. forebrain. The record shows two fairly long series of 15 mm. amplitude. Type 9 (2).

Record 9. Quincke tube was sounded into right ear of animal. Animal jumped. Electrode: lft. post. med. forebrain. The record shows regular extended activity which reaches 25 mm. in amplitude. Type 11 (4).

Record 10. Sounded quincke tube into right ear of animal. Animal passive. Electrode: lft. post. med. forebrain. The record shows irregular activity of 7 and 8 mm. amplitude scattered through the record. Type 13 (1).

Record 11. Sounded quincke tube into right ear of animal. Animal passive. Electrode: lft. post. med. post. forebrain. The first half of the record shows irregular small activity. The last half has a fairly long series which reaches 15 mm. in amplitude. Type 9 (2).

Record 12. Sounded quincke tube into right ear of animal. Animal jumped. Electrode: lft. post. lat. forebrain. The record commences with a long series which reaches 14 mm. in amplitude. The last half of the record shows small irregular activity. Type 9 (2).

Record 13. Hit animal's back with pencil. Animal winced. Electrode: lft. post. lat. forebrain. The record shows a short series of 16 mm. amplitude after the start of the record. There is another short series at the last of the record, of 18 mm. amplitude. The center of the record shows small irregular activity. Type 4 (4).

Record 14. Hit animal's back with pencil. Animal passive. Electrode: lft. post. lat. forebrain. The record shows scattered throws of 7 and 8 mm. amplitude throughout the record. Type 13 (1).

Record 15. Hit animal's back with pencil. Animal passive. Electrode: lft. post. med. forebrain. The record shows two fairly long series which reach 14 mm. in amplitude. One in the first half of the record and one in the last half. Type 9 (2).

Record 16. Hit animal's back with pencil. Animal passive. Electrode: lft. post. lat. post. forebrain. The first half of the record is fairly quiet. In the last half there are two short series which reach 15 mm. in amplitude. Type 8 (2).

Record 17. Hit animal's back with pencil. Animal passive. Electrode: lft. post. med. post. forebrain. The record shows spurious activity of large amplitude. Otherwise the record shows a short series of 14 mm. throws, in the center. Type 8 (2).

Record 18. Hit animal's back with pencil. Animal passive. Electrode: lft. mid. lat. forebrain. The record shows two fairly long series which reach 20 mm. in amplitude. Type 5 (4).

Record 19. Hit animal's back with pencil. Animal passive. Electrode: lft. ant. forebrain. The record shows extended activity which reaches 14 mm. in amplitude. The record is very regular. Type 9 (2).

Record 20. Hit animal's back with pencil. Animal passive. Electrode: lft. ant. lat. forebrain. The record shows extended irregular activity of 25 mm. in amplitude. Type 11 (4).

Record 21. Pulled animal's tail. Animal struggled. Electrode: lft. ant. forebrain. There is a long series of 40 mm. throws at the end of the first half of the record. There is another such series at the end of the record. Type 5 (4).

Record 22. Pulled animal's tail. Animal struggled. Electrode: left ant. med. forebrain. The record shows three long series which reach 20 mm. in amplitude. Type 5 (4).

Record 23. Pulled animal's tail. Animal struggled. Electrode: left post. med. post. forebrain. The record shows three long series which reach 15 mm. in amplitude. Type 9 (2).

Record 24. Pulled animal's tail. Animal passive. Electrode: lft. post. med. post. forebrain. The record shows a long irregular series which reaches 15 mm. in amplitude. There is considerable spurious activity on the record. Type 9 (2).

Record 25. Pulled animal's tail. Animal passive. Electrode: lft. ant. forebrain. The record shows a long irregular series which reaches 20 mm. in amplitude. Type 11 (4).

Record 26. Pulled animal's tail. Animal passive. Electrode:

lft. post. lat. post. forebrain. The record shows irregular scattered activity in a long series which reaches 12 mm. in amplitude. Type 9 (2).

Record 27. Pulled animal's tail. Animal passive. Electrode: lft. post. med. forebrain. The record shows a long irregular series which reaches 15 mm. in amplitude. Type 9 (2).

Record 28. Pulled animal's tail. Animal passive. Electrode: lft. post. lat. forebrain. The record shows irregular extended activity which reaches 30 mm. in amplitude. Type 11 (4).

Record 29. Animal had spontaneous 'jitters'--biting and swallowing. Electrode: lft. ant. forebrain. There are several short and abrupt series which reach 45 mm. in amplitude. Type 4 (4).

Record 30. Animal had spontaneous 'jitters'--biting and swallowing. Electrode: lft. mid. lat. forebrain. The record shows two fairly long series of 45 mm. amplitude. Type 5 (4).

Rat HH July 5, 1933, 8:00-9:30 p.m.

Description of Records: Record 1. Closed circuit. The record is negative. Type 1 (0).

Record 2. Animal passive in the dark. Electrode: lft. ant. forebrain. The record is negative. Type 1 (0)

Record 3. Animal passive in the dark. Electrode: lft. ant. lat. forebrain. The record is negative. Typel (0).

Record 4. Animal passive in the dark. Electrode: lft. ant. med. forebrain. The record shows irregular throws of 5 and 6 mm. amplitude throughout the record. Type 13 (1).

Record 5. Animal passive in the dark. Electrode: lft. post. lat. forebrain. The record shows a long irregular series of 10 mm. throws. Type 9 (2).

Record 6. Animal passive in the dark. Electrode: lft. post. med. forebrain. The last half of the record shows a short series of 10 mm. throws. Type 8 (2).

Record 7. Animal passive in the dark. Electrode: lft. post. lat. post. forebrain. The record shows a long series of 10 mm. throws. This series is irregular. Type 9 (2).

Record 8. Animal passive in the dark. Electrode: lft. post. med. post. forebrain. The record shows a long series of 10 mm. throws. This series is very irregular. Type 9 (2).

Record 9. Shined flashlight into animal's right eye. Electrode; lft. post. lat. post. forebrain. The record shows three short series of 8 mm. throws. Type 8 (2).

Record 10. Shined flashlight into animal's right eye. Electrode: lft. post. med. post. forebrain. The record shows scattered throws of 5 and 6 mm. amplitude throughout the record. Type 13 (1).

Record 11. Shined flashlight into animal's right eye. Electrode: lft. post. lat. forebrain. The record shows a fairly long series of 9 mm. throws. Type 9 (2).

Record 12. Shined flashlight into animal's right eye. Electrode: Lft. ant. med. forebrain. The record shows scattered throws of 5 and 6 mm. Type 13 (1).

Record 13. Shined flashlight into animal's right eye. Electrode: lft. ant. lat. forebrain. The record is negative. Type 1 (0).

Record 14. Shined flashlight into animal's right eye. Electrode: left ant. forebrain. The record is negative. Type 1 (0).

Record 15. Animal struggled spontaneously. Electrode: left. ant. lat. forebrain. The record shows extended irregular activity which reaches 25 mm. in amplitude. Type 11 (4).

Record 16. Animal struggled spontaneously. Electrode: lft. ant. forebrain. The record shows a short series of 10 mm. throws. Type 8 (2).

Record 17. Animal struggled spontaneously. Electrode: lft. post. lat. forebrain. The record shows irregular extended activity which reaches 45 mm. in amplitude. In the last third of the record there was movement of the electrode. Type 11 (4).

Record 18. Animal struggled spontaneously. Electrode: lft. post med. post. forebrain. The record is regularly active throughout, reaching an amplitude of 40 mm. Type 10 (4).

Record 19. Animal struggled spontaneously. Electrode: lft. post. lat. post. forebrain. The record shows two long series which reach 40 mm. in amplitude. There is one in the first half of the record and one in the last half. Type 5 (4).

(2). Relation Between Stimulus-Response Situations and Records - From the 342 records obtained on the rat, there were 14 behavior situations with sufficient distribution of data to warrant description. The areas in the rat have been fairly well described by Fortuyn (16), Gurdjian (19), Kappers (26), and Lashley (27). The anterior forebrain, anterior lateral and

medial forebrain, middle medial and part of the posterior medial forebrain, are supposedly motor in function. The middle lateral and part of the posterior lateral forebrain are somaesthetic in function. The posterior lateral and parts of the middle lateral and posterior lateral posterior forebrains are auditory. The rest of the posterior lateral posterior, the posterior medial posterior and the posterior medial forebrains are visual. It will be remembered that although these regions have been assigned these functions by the anatomist experiments like those of Lashley (27) have shown the various regions to be more or less equipotential for any given function.

(a). Animal Passive in the Room Light. The first behavior situation to consider is that of the animal passive in ordinary room illumination. See Table XLVI and Plate XXXII, figure 1. There is very slight activity under this condition, but

Table XLVI.

Brain Position	Record Type	Average Magnitude
RIGHT HEMISPHERE		
Ant. med. fore.	1, 1	0
Mid. lat. fore.	1	0
Mid. med. fore.	1	0
Post. lat. fore.	1	0
Post. med. fore.	12	1.0
Post. med. post. fore.	1	0
LEFT HEMISPHERE		
Ant. fore.	1	0
Ant. lat. fore.	1, 1, 13, 13, 8	.8
Ant. med. fore.	1, 1, 1, 1, 8, 1, 13	.43
Mid. lat. fore.	1, 1, 1, 1, 1, 1, 13, 1, 12	.4
Mid. med. fore.	1, 1, 1, 13, 13, 11	1.0
Post. lat. fore.	1, 8, 13, 8	1.2
Post. med. fore.	1, 1, 1, 13, 13, 13	.5
Post. lat. post. fore.	1	0
Post. med. post. fore.	1, 1, 1, 13	.25
	50 Records Average	.37

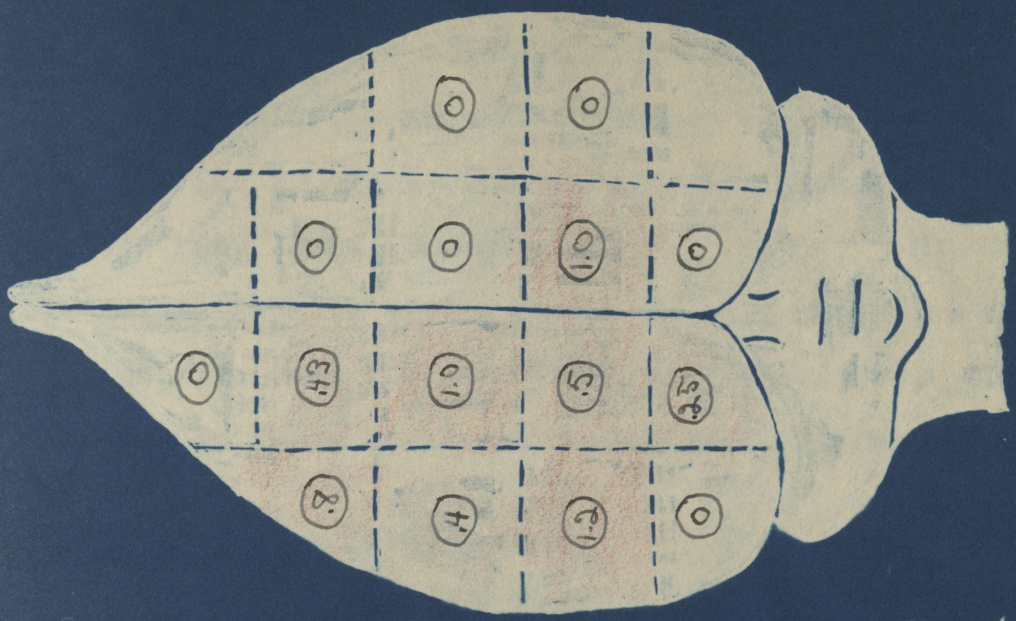

fig. 1

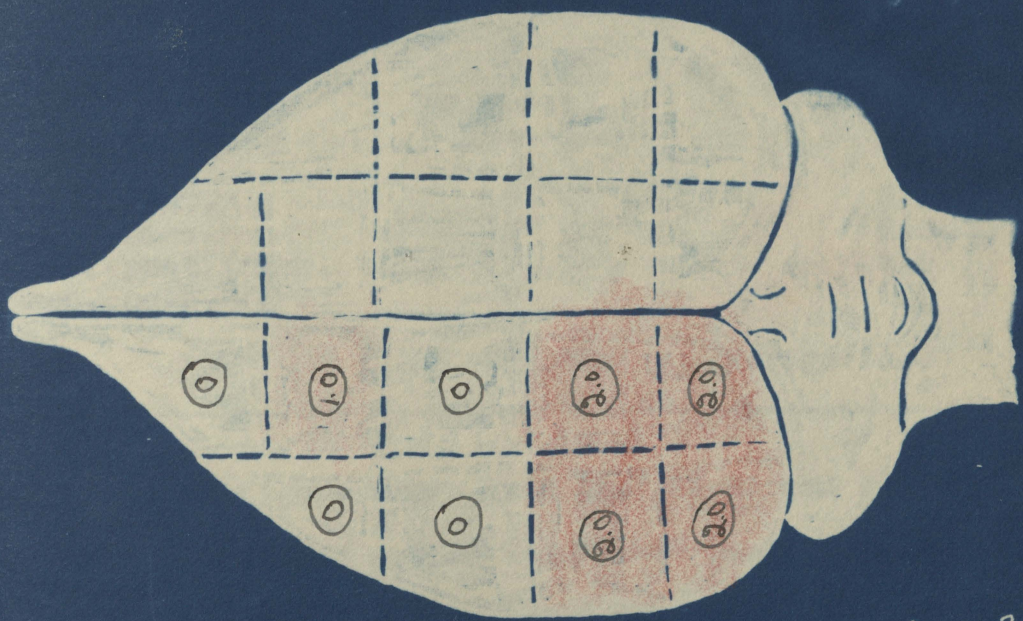

fig. 2

PLATE XXXII

the regions which show the most activity are the visual, auditory and the posterior portion of the motor region. The gradient is posterior in type. The average magnitude is .37 with the animal in room light, but passive.

(b). Animal Passive in the Dark. In this situation the animal was passive when the room light was turned out. The data are shown in Table XLVII and Plate XXXII, figure 2. Ex-

Table XLVII.

Brain Position	Record Type	Average Magnitude
LEFT HEMISPHERE		
Ant. fore.	1	0
Ant. lat. fore.	1	0
Ant. med. fore.	13	1.0
Mid. lat. fore.	1	0
Mid. med. fore.	1, 1	0
Post. lat. fore.	9	2.0
Post. med. fore.	8	2.0
Post. lat. post. fore.	9	2.0
Post. med. post. fore.	9	2.0
	10 Records	Average 1.00

amination of the figure shows that the visual and auditory regions become moderately active under this condition, while part of the motor region in the anterior forebrain is slightly active. There is a definite posterior gradient with a slight anterior pole. This seems to mean that, in the rat, the absence of the room light, which was on in all the other experiments, proved to be a 'visual stimulus', or at any rate, a 'cortical' stimulus. It might be conjectured that the animal was trying to hear and see in the dark. (Again, as will be explained later, this is not reasoning from structure to function). The average

magnitude, under this condition, was 1.00 as compared with .37 under the condition of room light, with the animal passive.

(c). Animal Passive When Flashlight Was Shined in Eye. Under this condition the flashlight was shined into the animal's right eye. All the data were taken from the left hemisphere. See Table XLVIII and Plate XXXIII, figure 1. There

Table XLVIII

Brain Position	Record Type	Average Magnitude
LEFT HEMISPHERE		
Ant. fore.	1	0
Ant. lat. fore.	1	0
Ant. med. fore.	13	1.0
Mid. lat. fore.	13	1.0
Mid. med. fore.	8, 1	1.0
Post. lat. fore.	9	2.0
Post. med. fore.	13	1.0
Post. lat. post. fore.	8	2.0
Post. med. post. fore.	13	1.0
	10 Records Average	1.00

is a much different gradient in this case from that which existed under darkness conditions. It is definitely posterior and lateral, including the visual, auditory, and parts of the somaesthetic and motor regions. The peaks which are of medium amplitude occur in the lateral visual and auditory regions. The average magnitude was 1.00, the same as with the animal in the dark.

(d). Animal Passive When Hit Foot or Back. In this situation the animal remained passive while the experimenter hit its foot or back with a pencil. The data are shown in Table XLIX

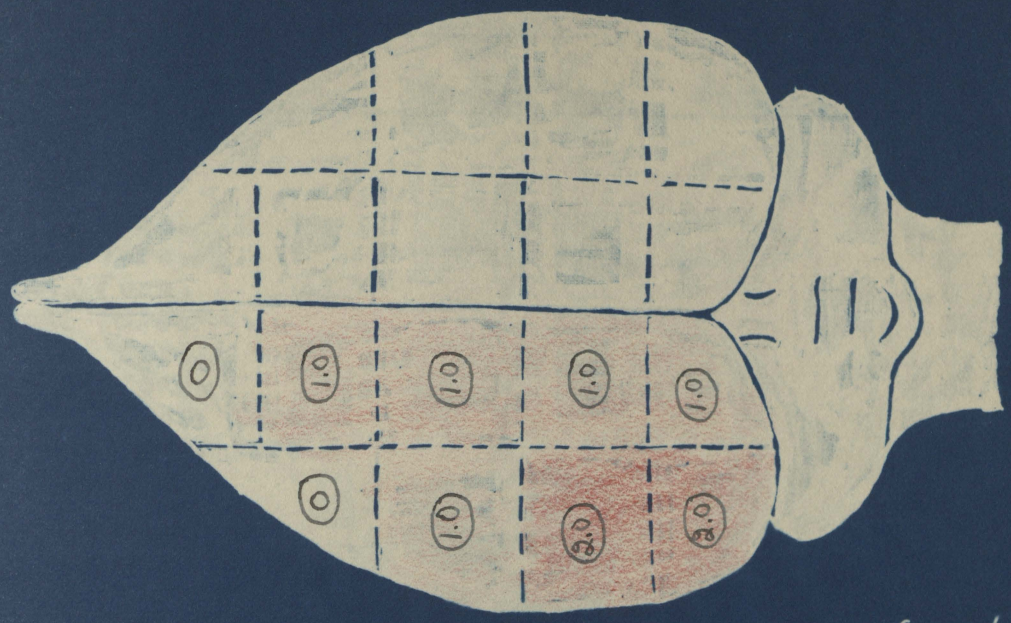

fig. 1

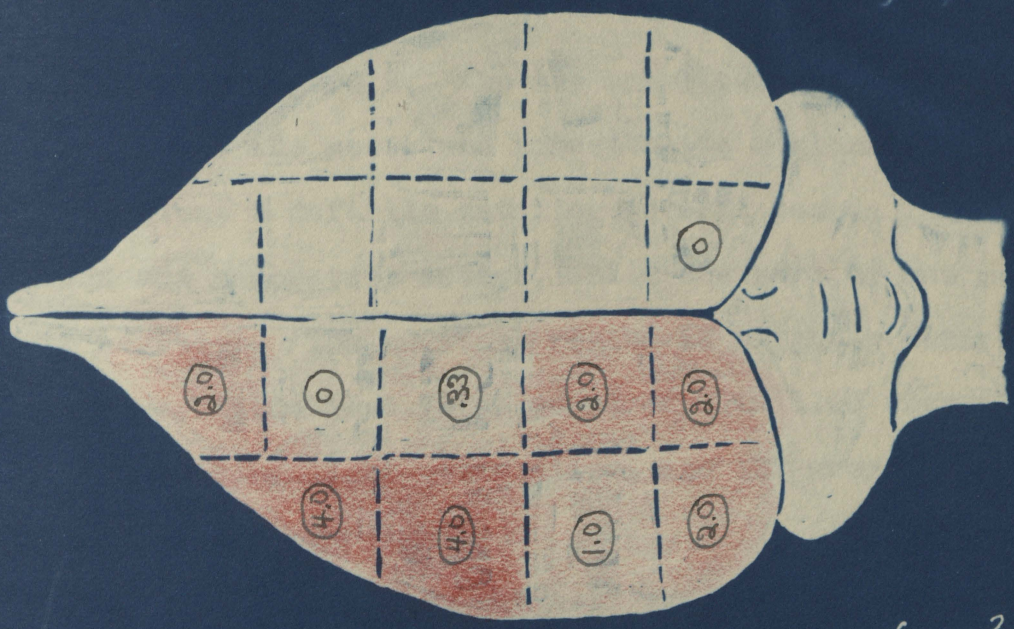

fig. 2

PLATE XXXIII

Table XLIX.

Brain Position	Record Type	Average Magnitude
LEFT HEMISPHERE		
Ant. fore.	9	2.0
Ant. lat. fore.	11	4.0
Ant. med. fore.	1, 1, 1, 1, 1	0
Mid. lat. fore.	5	4.0
Mid. med. fore.	1, 1, 13	.33
Post. lat. fore.	13	1.0
Post. med. fore.	9	2.0
Post. lat. post. fore.	8	2.0
Post. med. post. fore.	8	2.0
RIGHT HEMISPHERE		
Post. med. post. fore.	1	0
	16 Records Average	1.73

and Plate XXXIII, figure 2. The map shows two maximum regions. They are parts of the motor and somaesthetic regions, which give the gradient a definite anterior-lateral peak. The visual regions are moderately active, while one part of the motor region is negative. The auditory region is slightly active. The average magnitude is 1.73 as compared with 1.00 when the animal was receiving light stimulation, and .37 when the animal was passive in room light.

(e). Animal Wincing Very Slightly When Pulled Tail. In this behavior situation the animal was almost passive, but did wince slightly when its tail was pulled. The data are in Table L and Plate XXXIV, figure 1. It will be noted on examination of the plate that there are two peaks of maximum amplitude, one in the anterior forebrain, in the motor region, and the other in the auditory region. The visual region is moderately active, while the remainder of the motor area is negative. There is a definite anterior and posterior-lateral gradient in the distri-

Table L.

Brain Position	Record Type	Average Magnitude
LEFT HEMISPHERE		
Ant. fore.	11	4.0
Ant. lat. fore.	1, 1	0
Ant. med. fore.	1, 1, 1, 1, 1	0
Mid. lat. fore.	1, 8, 13	1.0
Mid. med. fore.	1, 1	0
Post. lat. fore.	11	4.0
Post. med. fore.	9, 8	2.0
Post. lat. post. fore.	9	2.0
Post. med. post. fore.	9	2.0
RIGHT HEMISPHERE		
Ant. med. fore.	13	1.0
Post. lat. fore.	1	0
	20 Records	Average 1.66

bution of activity over the brain. The average magnitude, under this condition, was 1.66 as compared with 1.73 with the animal wholly passive under tactual stimulation.

(f). Animal Wriggled or Struggled When Tail Was Pulled. In this behavior situation the animal wriggled or struggled when its tail was pulled. The data appear in Table LI and

Table LI.

Brain Position	Record Type	Average Magnitude
LEFT HEMISPHERE		
Ant. fore.	5	4.0
Ant. lat. fore.	13, 12	1.0
Ant. med. fore.	5	4.0
Mid. lat. fore.	11	4.0
Mid. med. fore.	5	4.0
Post. lat. fore.	2	4.0
Post. med. fore.	11, 2, 4	4.0
Post. lat. post. fore.	1	0
Post. med. post. fore.	9	2.0
RIGHT HEMISPHERE		
Mid. lat. fore.	11	4.0
Mid. med. fore.	10, 11	4.0
Post. med. post. fore.	10, 5	4.0
	17 Records	Average 3.25

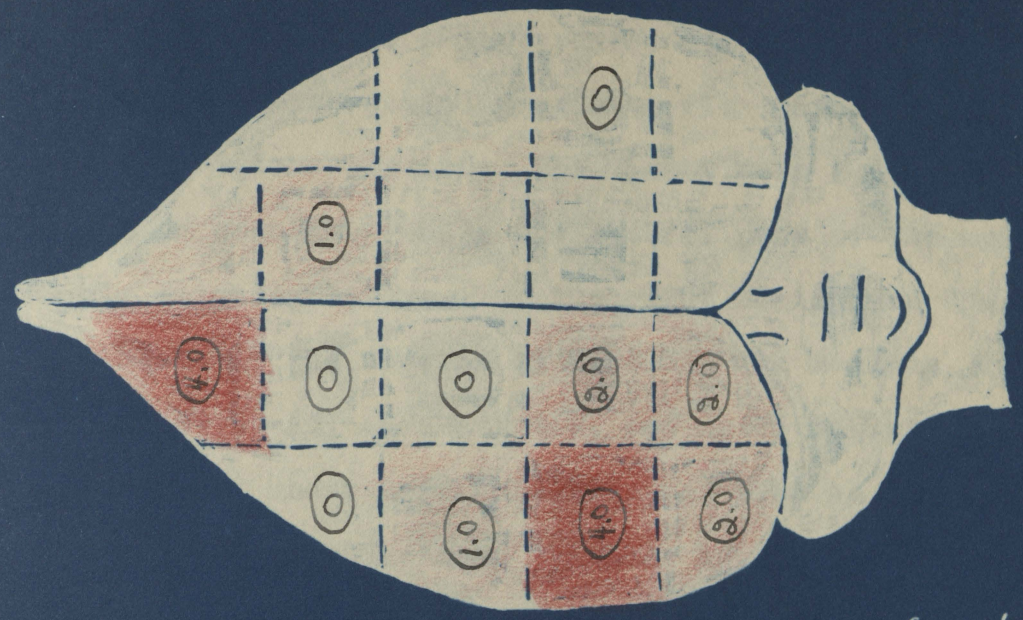

fig. 1

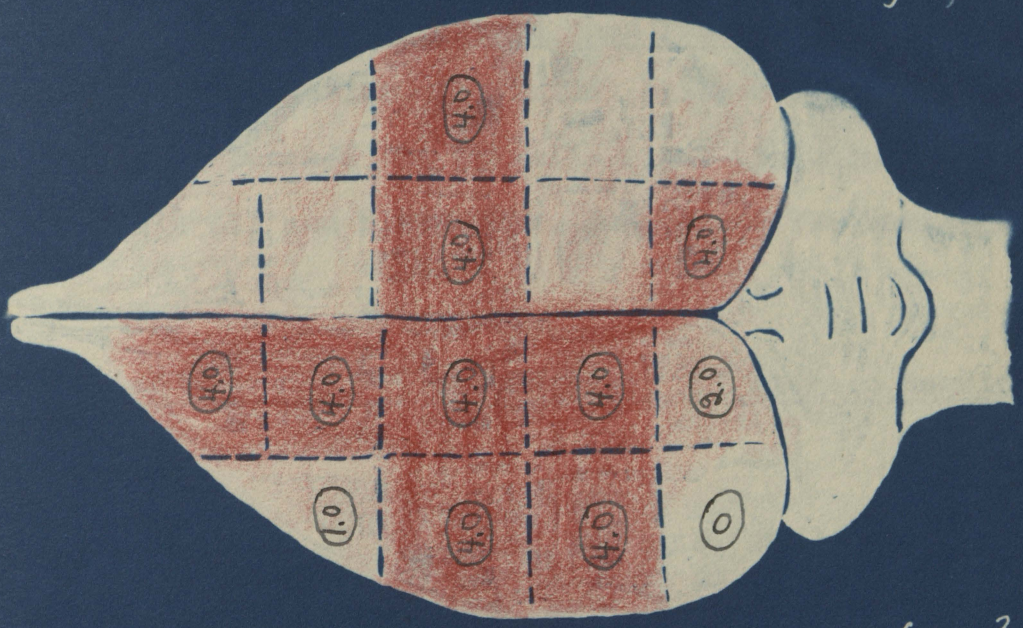

fig. 2

PLATE XXXIV

Plate XXXIV, figure 2. It will be noted that the left hemisphere shows an anterior-medial gradient, with maximum activity in most of the regions studied. The visual area is only moderately active or negative, while the lateral part of the motor area is only slightly active. In the right hemisphere the data are incomplete, but the regions studied are all maximum, including part of the visual, somaesthetic, and motor regions. The average magnitude, under this condition was 3.25 as compared with 1.66 when the animal winced slightly to tactual stimulation.

(g). Animal Blinked or Winced When Punched Right Eye. In this behavior situation, the animal blinked or winced when the experimenter punched the animal's right eye with the pencil. See Table LII and Plate XXXV, figure 1. The hemisphere

Table LII.

Brain Position	Record Type	Average Magnitude
LEFT HEMISPHERE		
Ant. fore.	12, 4	2.5
Ant. lat. fore.	13, 13, 9, 8, 11	2.0
Ant. med. fore.	8, 13, 11, 9, 8	2.2
Mid. lat. fore.	1, 5, 9, 5, 11	2.8
Mid. med. fore.	7, 9, 8, 5, 5, 11	3.0
Post. lat. fore.	2, 9, 7	2.6
Post. med. fore.	4, 8, 2, 12	2.7
Post. lat. post. fore.	13, 13	1.0
Post. med. post. fore.	8, 8-	1.7
	34 Records Average	2.27

is almost homogeneously active at a medium level of amplitude. There is a small peak in the motor region, with a slight indication of a middle medial gradient. The visual regions are

the least active, just above the level of slight activity. The average magnitude was 2.27 as compared with 1.66 when the animal winced slightly to tactual stimulation.

(h). Animal Passive When Punched Right or Left Eye. In this behavior situation the animal remained passive while the right or the left eye was punched with the pencil. The data are given in Table LIII and Plate XXXV, figure 2. The data

Table LIII.

Brain Position	Record Type	Average Magnitude
LEFT HEMISPHERE		
Ant. med. fore.	1	0
Mid. med. fore.	1, 1	0
Post. lat. fore.	1	0
Post. med. fore.	1	0
RIGHT HEMISPHERE		
Ant. med. fore.	13	1.0
Mid. lat. fore.	13	1.0
Mid. med. fore.	13	1.0
Post. med. post. fore.	8	2.0
	9 Records	Average .55

are incomplete, but there is a type of posterior gradient, which reaches a medium level in the visual region. All of the positions on the left hemisphere are negative. The average magnitude was only .55 as compared with 1.66 when the animal was passive to the tactual stimulation of hitting foot or back.

(i). Animal Winced or Whined When Tapped or Hit Head or Back. In this situation the animal winced or whined when the experimenter tapped or hit its head or back with the pencil. See Table LIV and Plate XXXVI, figure 1. Both hemispheres

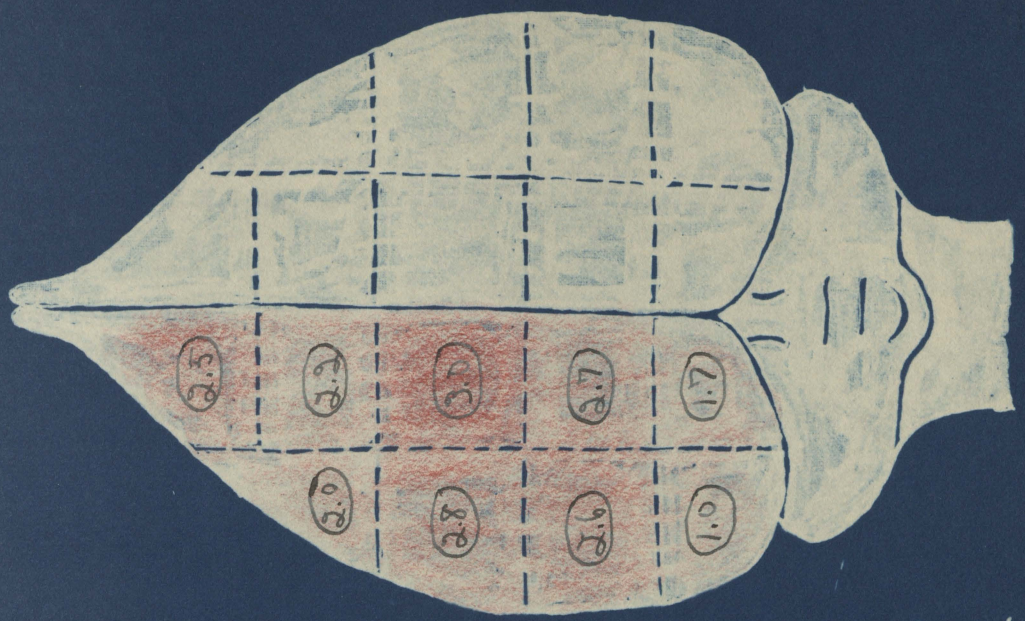

fig. 1

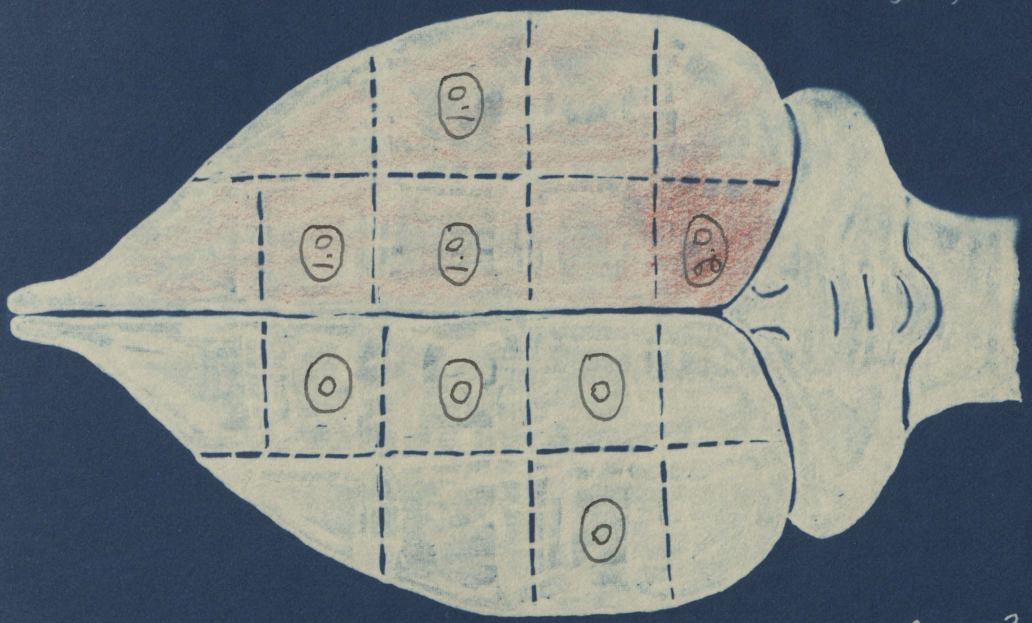

fig. 2

PLATE XXXV

are fairly homogeneously active at a low to medium level of

Table LIV.

Brain Position	Record Type	Average Magnitude
LEFT HEMISPHERE		
Ant. fore.	8	2.0
Ant. lat. fore.	8, 1, 9, 13	1.2
Ant. med. fore.	9, 12, 13, 1, 8	1.2
Mid. lat. fore.	13, 13, 13, 9	1.2
Mid. med. fore.	8, 8, 13, 1, 9, 13	1.3
Post. lat. fore.	9, 4	3.0
Post. med. fore.	8, 13, 9+, 13	1.7
Post. lat. post. fore.	1	0
Post. med. post. fore.	8-, 9+, 9, 9	2.1
RIGHT HEMISPHERE		
Mid. med. fore.	13, 13	1.0
Post. lat. fore.	13	1.0
Post. med. post. fore,	13, 13	1.0
	36 Records Average	1.52

magnitude. There is one posterior peak in the left hemisphere, in the auditory and somaesthetic region. There is also a moderately active peak in the forward part of the motor region, so that the general trend of the gradient is anterior-posterior. The average magnitude was 1.52 as compared with 1.66 when the animal was passive to hitting of foot or back and .55 when the animal was passive to punching of the eyes.

(j). Animal Stiffened or Struggled When Hit or Punched Back. In this behavior situation the animal stiffened or struggled when the experimenter hit or punched its back. The data are presented in Table LV and Plate XXXVI, figure 2. Examination of the figure shows that the animal's brain is highly active under this condition. The high peaks occur in the medial visual region, the motor and somaesthetic regions.

There is a posterior to lateral to anterior type of gradient. The regions explored in the right hemisphere agree very well with those of the left hemisphere. The regions of medium activity include the forward portion of the visual region and the lateral portion of the motor and somaesthetic regions. The average magnitude is 3.44 as compared with 1.52 when the animal winced or whined to tactual stimulation.

Table LV.

Brain Position	Record Type	Average Magnitude
LEFT HEMISPHERE		
Ant. fore.	5	4.0
Ant. lat. fore.	13, 11	2.5
Ant. med. fore.	2, 11, 4	4.0
Mid. lat. fore.	2, 2, 11	4.0
Mid. med. fore.	4, 11, 5, 5	4.0
Post. lat. fore.	2, 11, 9	3.3
Post. med. fore.	9	2.0
Post. lat. post. fore.	9+	3.0
Post. med. post. fore.	4	4.0
RIGHT HEMISPHERE		
Ant. med. fore.	9	2.0
Mid. med. fore.	11	4.0
Post. lat. fore.	4	4.0
Post. med. post. fore.	10	4.0
	23 Records Average	3.44

(k). Animal Spontaneously Biting, Swallowing or Breathing Hard (Jitters). Under this situation the animal was making spontaneous movements of biting, swallowing periodically, 'jittering', or was breathing very hard. The data are in Table LVI and Plate XXXVII, figure 1. Examination of the figure shows a definite anterior-posterior gradient with a long band of maximum amplitude along the lateral aspect of the cortex. The maximum regions include part of the visual, the auditory, the som-

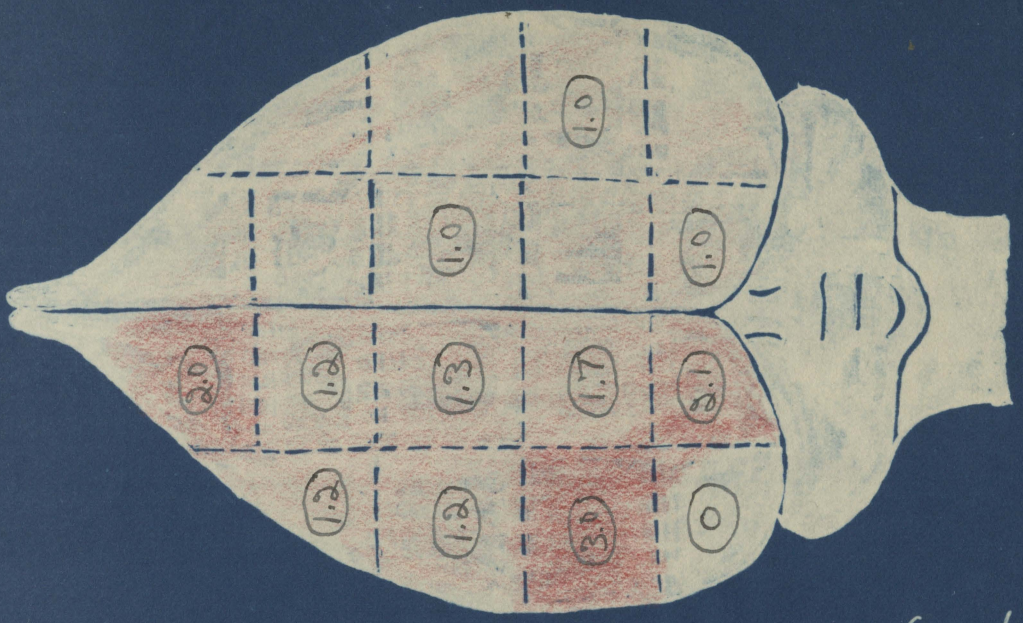

fig. 1

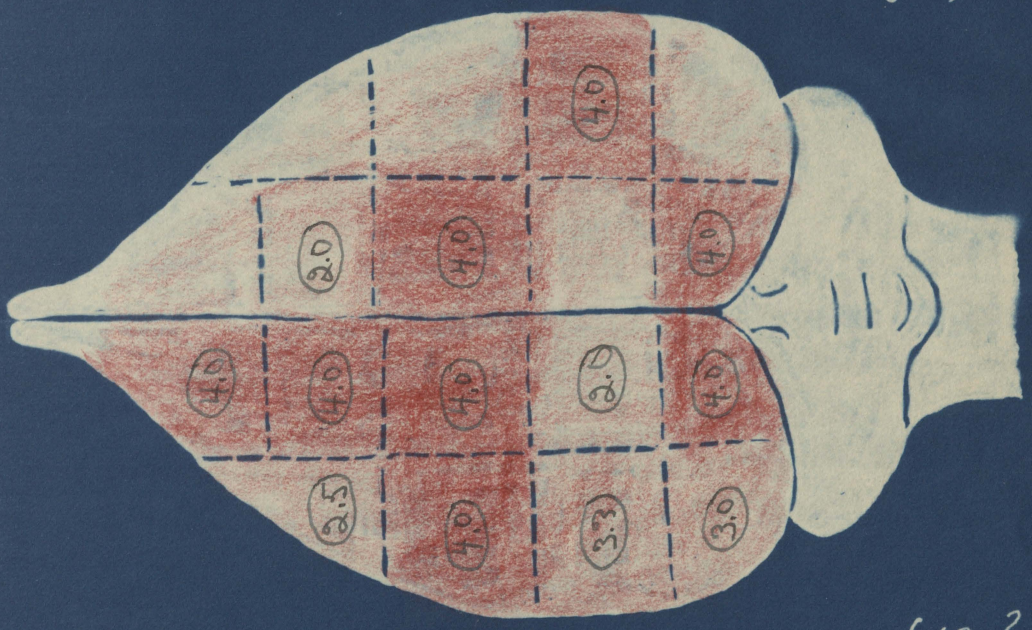

fig. 2

PLATE XXXVI

aesthetic and the forward part of the motor region. The data from the right hemisphere, as far as they go, show a correlation with the left. A medial band in the left, which includes the rest of the motor and visual regions is only slightly to moderately active. The average magnitude is 2.80.

Table LVI.

Brain Position	Record Type	Average Magnitude
LEFT HEMISPHERE		
Ant. fore.	11, 4	4.0
Ant. lat. fore.	9	2.0
Ant. med. fore.	12	1.0
Mid. lat. fore.	5	4.0
Mid. med. fore.	8, 9	2.0
Post. lat. fore.	2	4.0
Post. med. fore.	13, 8	1.5
Post. lat. post. fore.	9,8	2.0
Post. med. post. fore.	3	4.0
RIGHT HEMISPHERE		
Post. lat. fore.	3	4.0
	14 Records	Average 2.80

(1). Animal Spontaneously Struggling, Moving Head, or Wincing. Under this behavior situation the animal was spontaneously struggling, moving its head or wincing. The data appear in Table LVII and Plate XXXVII, figure 2. The map shows a definite anterior-posterior gradient, with the entire visual and auditory regions maximum, at the posterior pole. The anterior pole of activity occupies most of the motor regions, although the extreme forward end is only moderately active. The somaesthetic region is also only moderately active. The gradient is similar to that obtained in the other spontaneous situation, but is more widespread in the number of maximum re-

gions. There is more activity in the motor regions and less in the somaesthetic. The average magnitude, in this case, is 3.50 while that under the other spontaneous condition was 2.80.

Table LVII.

Brain Position	Record Type	Average Magnitude
LEFT HEMISPHERE		
Ant. fore.	8	2.0
Ant. lat. fore.	11	4.0
Ant. med. fore.	11	4.0
Mid. lat. fore.	9	2.0
Mid. med. fore.	11, 8	3.0
Post. lat. fore.	11	4.0
Post. med. fore.	4, 10	4.0
Post. lat. post. fore.	5	4.0
Post. med. post. fore.	10	4.0
RIGHT HEMISPHERE		
Post. med. fore.	11, 11	4.0
	13 Records	Average 3.50

(m). Animal Passive When Sounded Quincke Tube or 325 Fork. This behavior situation is the first of the group on sound stimulation. The animal remained passive when the 1024 d.v. quincke tube was sounded or when the 325 d.v. tuning fork was struck. The data are in Table LVIII and Plate XXXVIII, figure 1. All the regions are of medium amplitude or below. There are two definite peaks of medium amplitude, one in the anterior pole in the motor region, and the other in the posterior medial pole, in the visual region. The auditory region is very slightly active along with a band of regions in the middle portion of the cortex. The average magnitude, under this condition, was .67 on the evaluation scale.

(n). Animal Winced, Blinked or Wiggled Whiskers With

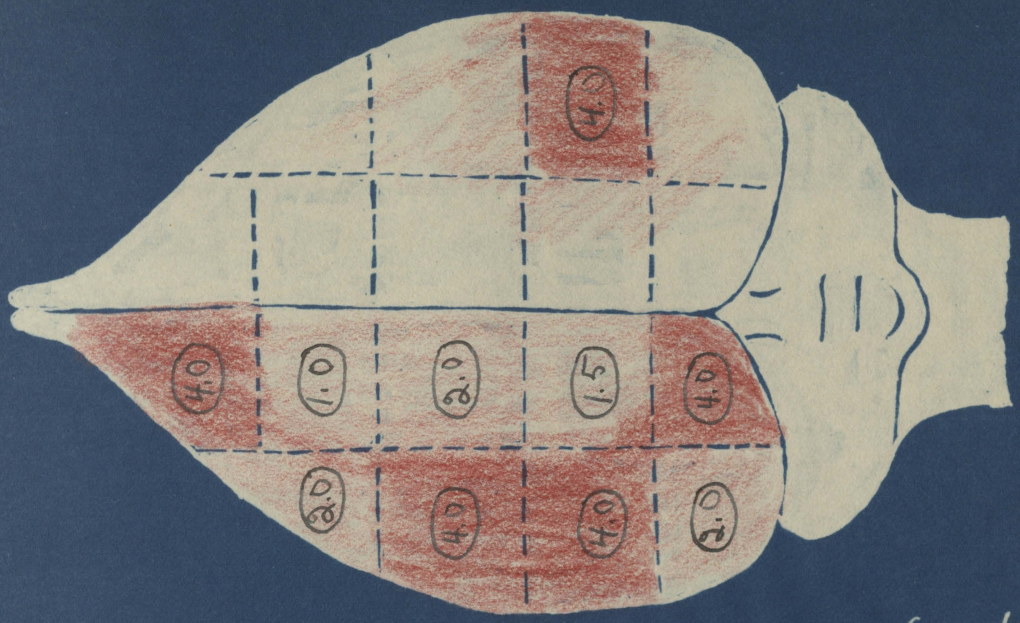

fig. 1

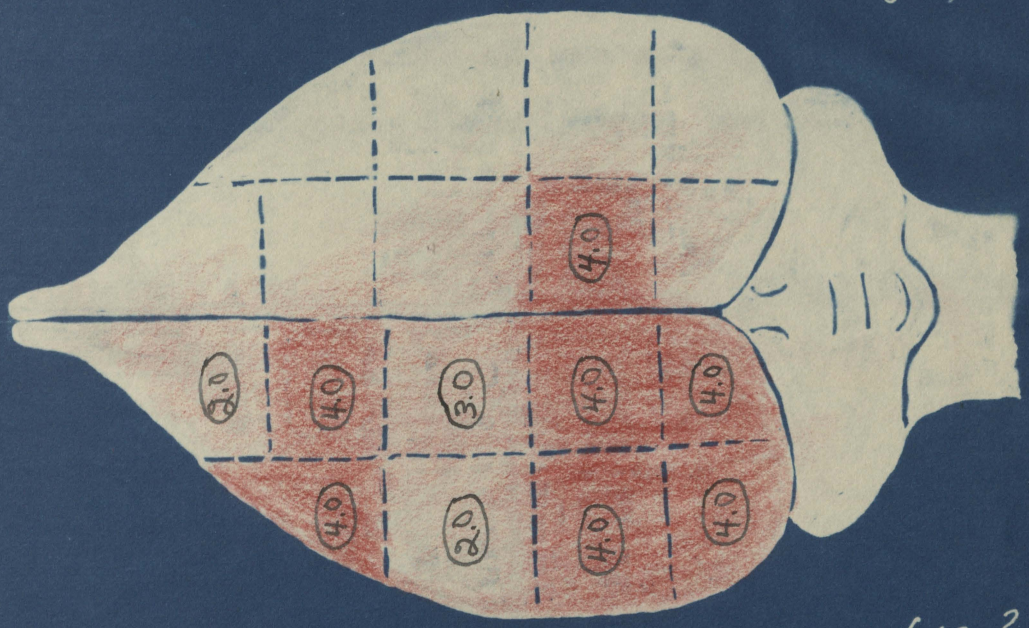

fig. 2

PLATE XXXVII

QUINCKE TUBE. The next behavior situation was when the 1024

Table LVIII.

Brain Position	Record Type	Average Magnitude
LEFT HEMISPHERE		
Ant. fore.	9	2.0
Ant. lat. fore.	1, 1, 1	0
Ant. med. fore.	1	0
Mid. lat. fore.	1, 12	.5
Mid. med. fore.	1, 1, 8	.60
Post. lat. fore.	1, 12	.5
Post. med. fore.	13, 1	.5
Post. lat. post. fore.	1, 1	0
Post. med. post. fore.	9	2.0
	17 Records Average	.67

d.v. quincke tube was sounded and the animal responded by wincing, blinking, or wiggling its whiskers. See Table LIX and

Table LIX.

Brain Position	Record Type	Average Magnitude
LEFT HEMISPHERE		
Ant. fore.	8	2.0
Ant. lat. fore.	12, 13, 8, 1	1.0
Ant. med. fore.	13, 13	1.0
Mid. lat. fore.	9, 12, 5, 2	2.7
Mid. med. fore.	9, 5, 2	3.3
Post. lat. fore.	9	2.0
Post. med. fore.	8, 12, 12, 2, 11	2.4
Post. lat. post. fore.	1	0
Post. med. post. fore.	12, 7	1.5
	23 Records Average	1.76

Plate XXXVIII, figure 2. Examination of the plate shows a much higher level of activity under this condition than under passive condition to sound. The highest peak occurs in the middle motor region, so that the general contour of the gradient is middle-medial. The visual regions are slightly less

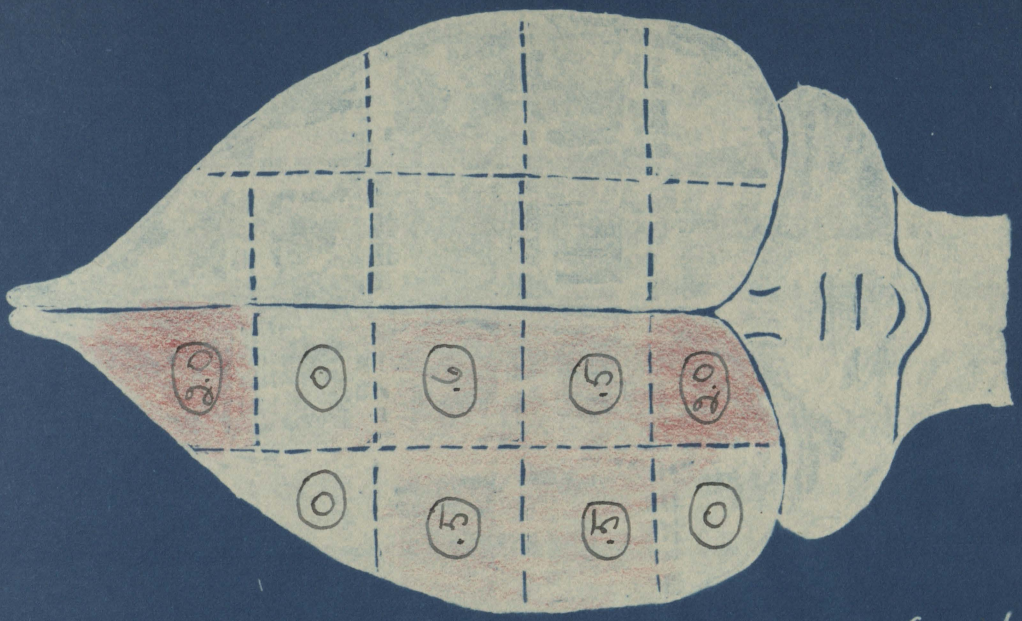

fig. 1

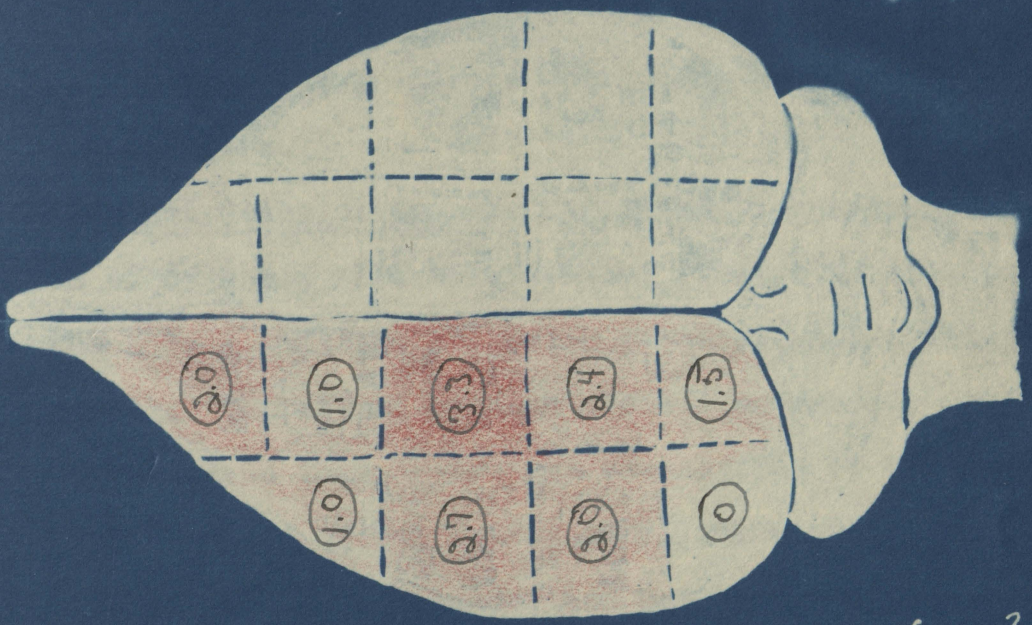

fig. 2

PLATE XXXVIII

active than under passive to sound. The auditory region is moderately active. The whole gradient has been raised from slight to medium activity. The average magnitude is 1.76 as compared with .67 under passive to sound stimulation.

(3). Conclusions on the Mammal - The data just presented, on the rat, can be summarized under six heads: light stimulation; tactual stimulation with the animal passive; tactual stimulation with the animal active; pain stimulation with the animal responding; spontaneous activity of the animal; and auditory stimulation. In the section which follows, each of these will be discussed with reference to the gross average magnitudes and the types of gradients which appear under the respective conditions.

(a). Light Stimulation. To facilitate comparison, the condition of darkness will be discussed first, In (b), (darkness), there is a definite posterior gradient with a slight anterior pole. The visual regions are all moderately active. This probably means that in the rat the absence of the room light proved to be a visual and auditory stimulus in the sense that the animal was trying to see and hear. The average magnitude, under this condition, was 1.00. Activity in situations (a), animal passive to room illumination, is low throughout, but the gradient is somewhat posterior in type. The visual regions are very slightly active or negative. This fact may be interpreted to mean that, since the animal had been subjected to room light for a long period of time prior to the recording, a type of adaptation had taken place. The average magnitude in this case is .37 as compared with 1.00 when the

animal was passive in the dark. In group (c) a definite visual stimulus was given; the flashlight was shined into the animal's right eye. The gradient, in this case, is definitely posterior-lateral, including the visual, auditory and parts of the somaesthetic and motor regions. The gradient is spread out more homogeneously than under the darkness condition. The peaks are in the auditory and lateral visual regions. The average magnitude is 1.00 as compared with .37 when the animal was passive in the room light and 1.00 when the animal was passive in the dark. A gross average of the two situations which involve objective light stimulation gives .68 as compared with 1.00 when the animal was passive in the dark. It seems the more likely, then, that darkness acted as a differential stimulus.

(b). Animal Passive to Tactual Stimulation. The first situation in group (d) consisted of the animal passive while the experimenter hit its foot or back with a pencil. The gradient is definitely anterior-lateral, with peaks located in parts of the motor and somaesthetic regions. The visual regions are moderately active while a part of the motor region is negative. The average magnitude in this situation, was 1.73 as compared with .37 when the animal was passive to room light, and 1.00 when the animal was passive in the dark. The next situation, (h), is animal passive when its right or left eye was punched. A type of posterior gradient appears although the level of magnitude is low. The peak occurs in the visual region. The average magnitude is .55 as compared with 1.73 when the animal was passive with its foot or back hit, and

.37 when the animal was passive in the room light. The average of the situations in this group gives 1.14 as compared with an average of .68 under light stimulation and 1.00 with the animal passive in the dark.

(c). Animal Responding to Tactual Stimulation. The first behavior situation in this group, (e), is when the animal winced slightly as the experimenter pulled its tail. There is a posterior-anterior gradient with two peaks which stand out markedly at a maximum level of magnitude. These are located in the anterior motor region and in the auditory region. The average level of magnitude for this situation is 1.66 as compared with .37 when the animal was passive in the room light. The next situation, (g), consists of animal wincing or blinking when its right eye was punched with the pencil. In this case the cortex becomes almost homogeneously active at a medium level of amplitude. There is a small peak in the motor region, with a slight indication of a middle medial gradient. The visual regions are the least active. This gradient differs from (e) in the greater activity of the whole motor region and in the elimination of high peaks. The gross average amplitude, under this condition, was 2.27 as compared with 1.66 under (e) and .37 when the animal was passive in the room light. The third behavior situation in this group, (i), consists of the animal wincing or whining when its head or back was tapped with the pencil. The cortex shows a gradient which is almost homogeneously active at a low level of amplitude. There is, however, one peak of maximum magnitude in the auditory and somaesthetic regions, and a medium peak in the forward part of the motor

region. The general trend of the gradient is suggestive of an anterior-posterior type. The gross average magnitude, in this case, is 1.52 as compared with 2.27 when the animal's eye was punched, and 1.66 under (e). The gross average of all the situations in this group is 1.81 as compared with 1.14 when the animal was passive to tactual stimulation, .68 under light stimulation, and 1.00 with the animal passive in the dark.

(d). Animal Responding to Pain Stimulation. In this group of situations the animal responded to pain stimulation. The first situation, (f), was when the animal wriggled or struggled as the experimenter pulled its tail. The gradient is an anterior-medial type, with maximum activity in most of the regions explored. This visual regions and the lateral part of the motor region are the least active. There is a long medial band of maximum regions extending from the anterior pole to the visual region in the posterior pole. The average magnitude, under this condition, was 3.25 as compared with the average of 1.81 when the animal was active to tactual stimulation and 1.14 when the animal was passive to tactual stimulation. The next situation, (j), consisted of the animal stiffening and struggling when its back was hit or punched with the pencil point. There is an anterior-medial-posterior gradient, with peaks in the medial visual, motor, and somaesthetic areas. Regions of medium activity include the forward portion of the visual area and the lateral portions of the motor and somaesthetic regions. The average magnitude, under this condition, was 3.44 as compared with 3.25 when the animal's tail was pulled vigorously, 1.81 when the

animal was active to tactual stimulation, and 1.14 when the animal was passive to tactual stimulation. The average of the two situations in this group gives 3.34 as compared with the average of 1.81 when the animal was active to tactual stimulation, 1.14 when the animal was passive to tactual stimulation, .68 when the animal was stimulated by light, and 1.00 when the animal was passive in the dark.

(e). Spontaneous Activity of the Animal. The first behavior situation, (k), showed the animal biting, swallowing, jittering, or breathing hard with no differential stimulation except the ordinary room light. The gradient that now appears definitely anterior-posterior with a long band of maxima along the lateral aspect of the cortex. The highly active regions include part of the visual, the auditory, the somaesthetic and the forward part of the motor regions. The average magnitude in this case was 2.80 as compared with 3.34 when the animal was active to pain stimulation and 1.81 when the animal was active to tactual stimulation. The next behavior situation, (l), was with the animal struggling, moving its head, or wincing under no differential stimulation. The gradient is again anterior-posterior in type, but shows a wider maximum distribution than in situation (k). In the posterior pole the entire visual and auditory regions are at a maximum. The anterior pole occupies most of the motor region, except the extreme anterior part, which is moderately active. The gradient is more widespread under this condition than under (k), with more activity in the motor region and less in the somaesthetic. The average magnitude, under this condition, is 3.50 as compared with 2.80 under

(k) and 3.34 as the average for response to pain stimulation. The gross average of the two situations in this group gives 3.15 as compared with 3.34 when the animal was active to pain stimulation, 1.81 when the animal was active to tactual stimulation, 1.14 when the animal was passive to tactual stimulation, .68 when the animal was under light stimulation, and 1.00 when the animal was passive in the dark.

(f). Auditory Stimulation. In this group situation, (m), the animal was passive when a 1024 d.v. quincke tube or 325 d.v. tuning fork was sounded. The gradient is definitely anterior-posterior, with the medial aspect of the visual and the forward end of the motor areas moderately active. The auditory, somaesthetic and the rest of the visual area are only very slightly active. The average magnitude, under this condition, is .67 as compared with .68 when the animal was stimulated with light or 1.00 when the animal was passive in the dark. In the next situation, (n), the animal was wincing or blinking or wiggling its whiskers when the 1024 tuning fork was sounded. In this case a much higher level gradient occurred, with the highest peak in the middle motor region. The general contour of the gradient is middle-medial, with the auditory region moderately active, along with part of the visual, somaesthetic, and motor regions. The whole gradient has risen from slight activity under (m) to medium activity. The average magnitude, under this behavior condition, is 1.76 as compared with .67 when the animal was passive under auditory stimulation. The average of the two situations with sound stimulation gives 1.21 as compared with .68 as an average under visual stimulation, 1.00 when the ani-

mal was passive in the dark, 1.14 when the animal was passive to tactual stimulation, 1.81 when the animal was active to tactual stimulation, 3.34 when the animal was active to pain stimulation, and 3.15 when the animal was responding spontaneously.

VIII. COMPARISON OF ANIMAL GROUPS

In all, 1195 separate records were obtained in this investigation. These records can be divided into seven groups on the basis of the stimulus and the resulting response of the animal. Practically all of these groups are represented in each of the five types of animal. They are: light stimulation with the animal passive; tactual stimulation with the animal passive; tactual stimulation with the animal active; pain stimulation with the animal active; spontaneous activity of the animal; tactual and visual stimulation with the animal active; and auditory stimulation. These groups will be discussed with reference to each animal type, both from the standpoint of the average magnitude of the records, and the types of gradients which were found.

(1). Light Stimulation - (a). Animal Passive in the Dark. In the crayfish the average magnitude, in the situation of passive to darkness, was .20. A low amplitude diagonal gradient appeared with activity in the olfactory, association and part of the motor region. This behavior situation in the frog gave an average magnitude of .39. The gradient is low, with small peaks in the visual and auditory regions. In the pigeon the average magnitude, under this condition, was .35. The gradient in this case becomes a posterior type with a peak in the visual area. This change to the visual region can probably be understood in light of the highly structured visual field of the pigeon. Possibly the animal was trying to see in the dark. In the case of the rat the average magnitude was 1.00. The

gradient is definitely posterior, with a slight anterior pole. Again it would seem that the animal was trying to see, and, in this case, hear also, since the auditory region becomes active. The average of all the animal forms under this condition is .48. As we ascend the animal scale the visual cortex becomes more active when the animal is in the dark, giving a definite posterior type of gradient. This is probably correlated with the greater degree of visual structurization in the higher animal forms. A similar trend seems to appear in connection with the auditory area.

(b). Animal Passive in the Room Light. In this case the animal was passive in ordinary room illumination. The average magnitude of the records, in the crayfish, was .58 as compared with .20 under darkness. The gradient in this case becomes more extended in the anterior pole, of visual function, which is nearly homogeneously active. The records from the frog, under this condition, average .42, as compared with .39 when the animal was passive in the dark. The gradient increases in level, but is similar in nature to that with the animal passive in the dark. The activity occurs in the visual and auditory regions. There is relatively less activity, under room light, in the frog than in the crayfish. In the snake the average magnitude, under room light, is .14. In this case the olfactory-and-somatic region is the only one which shows activity. The average magnitude in the pigeon is .21 as compared with .35 when the animal is passive in the dark. The gradient in this case is medial and lateral with very slight activity of any kind. The visual region is negative, which suggests a type of adap-

tation, while the higher level, occurring under darkness, suggests that darkness was really a visual stimulus. In the rat the average magnitude under this condition was .37 as compared with 1.00 when the animal was passive in the dark, which shows in a more striking way, still, that darkness must have been a 'visual'and an 'auditory' stimulus. The difference between the two is .14 in the pigeon, but jumps to .63 in the rat. A sufficient number of records were taken to make the comparisons reliable. It would seem, therefore, that as we ascend the animal scale darkness disturbs the cortex, momentarily, at least progressively to a greater extent. The gradient, in the rat, (under room light), is somewhat posterior in type, but with very slight activity in the visual region. The fact again appears that evidently after the animal is subjected to a light for a long period, a type of adaptation goes on which reduced cortical activity. The average for all the animals, under the condition of room light, was .34 as compared with the average of .48 under the condition of darkness. It will be noted that two opposite types of differentiation are taking place as to visual functions of the brain. In case of darkness, suddenly introduced, the activity of the brain increases as we ascend the animal scale, and the increase progresses toward the visual pole. Secondly, under a continuous room light condition, as we ascend the animal scale, the amount of brain activity decreases, perhaps due to adaptation. The decrease progresses toward the visual pole. It is interesting to note that the opposite situation was found in the crayfish, where the visual pole was relatively more sensitive in room light and less active in the dark.

(c). Animal Passive With Flashlight Stimulation. The next condition is a definite visual stimulus (flashlight) shined into the animal's eye. In the crayfish the average magnitude of disturbance was 1.24. The gradient is more extended and at a higher amplitude than in the room light situation and shows a peak in the left visual-and-olfactory region. This may be related to the fact that the visual stimulus was given in the right eye of the animal. The head of the gradient is still anterior. In case of the frog the average magnitude is also 1.24. The gradient rises in level over that of room light and is extended over a wider region. This gradient is diagonal, a fact probably related to the crossing of the optic tracts. The cerebellum appears slightly active under this condition. No data were obtained from the snake. In the pigeon the average magnitude was 1.10. There appears a transcortical gradient with its highest peak in the visual region, with an indication of an anterior peak in the motor region. In the case of the rat the average magnitude, under the flashlight condition, was 1.00. The gradient is definitely posterior-lateral, including the visual, auditory and parts of the somaesthetic and motor regions. The average for all the animals under the flashlight stimulus was 1.14 as compared with .34 under room light conditions and .48 when the animal was passive in the dark. In other words the level of magnitude is nearly three times as great as when under room light and over twice as great as when the animal is in the dark. It will be noted that, under the flashlight condition, as one ascends the animal scale, the height of activity of the brain gradually decreases, while at the same time the structur-

ization of the visual apparatus is increasing. The lower the animal in the evolutionary scale the fewer are the quiescent areas.

An additional type of visual stimulus was used with the frog, a flickering light, which gave an average magnitude of 1.40 as compared with the general average of 1.14 with the flashlight, .34 with room light and .48 with the animal in the dark.

(d). Average Light Situation. The averages have been calculated for all the light situations in each animal group. In the crayfish this was .91 as compared with .20 with the animal in the dark. In the frog the average was 1.02 as compared with .39 in the dark. In the snake the average was .14 for the room light situation. The average in the pigeon was .65 as compared with .35 in the dark. In the rat the average was .68 as compared with 1.00 in the dark. The average for all the animals under light stimulation is .68 as compared with .48 in the dark. The magnitude of disturbance, under light, more nearly approaches what it is in darkness as one comes up the scale until we reach the rat. Then the darkness condition produces a greater disturbance than is the average under light conditions.

(2). Animal Passive to Tactual Stimulation - (a). Passive When Hit Leg or Back. In this case the animal remained passive under the tactual stimulation of having its leg or back hit with the pencil. In the crayfish the average magnitude was 2.50. The gradient shows a definite rise in level, particularly in the anterior portion of the brain, which has a sensory function. In the frog the average magnitude was 1.25. The gradient in-

volved the visual, olfactory, auditory and motor regions, at a medium level of disturbance. Visual activity can be accounted for, in part, by the fact that the room light was on, but this does not explain the activity in the other regions. In the snake there was no activity. In the pigeon the average magnitude was .55. A definite anterior-posterior gradient appears with peaks in the motor and visual regions. (The level of .55 is over twice the .21 under the room light, and higher than the .35 with the animal in the dark.) In the rat the average magnitude is 1.73. The gradient is also definitely anterior-posterior, showing peaks in parts of the motor and somaesthetic regions, and the visual areas. The average for all the animals, under this situation, was 1.20 (as compared with .68 for light stimulation and .48 with the animal in the dark.) As we come up the animal scale the gradients show a change from homogeneity toward a definite anterior-posterior form, while at the same time, there is a rapid reduction in the average activity.

(b). Animal Passive When Punched Eye. Not all of the animals were represented in this group. The crayfish gave an average magnitude of 2.00, as compared with 2.50 when its leg or back was hit. The gradients in the two cases are very similar, showing a rise in the level of activity, over room light. In both cases this increase was confined to the sensory half of the brain. In the rat, the average magnitude under this condition (b), was .55 as compared with the 1.73 in situation (a), passive when leg or back was hit. In (b) a posterior gradient appears, with a peak in the visual regions. The anterior pole

characteristic of the gradient in (a) has disappeared which doubtless accounts for the reduction in amplitude of (b) as compared with (a). Still, as in the crayfish, the activity is confined (b) to sensory regions, but is less in amplitude. The average for the two animals in this group is 1.27 as compared with 1.20 when the animal was passive to hitting of leg or back.

(c). Average Passive to Tactual Stimulation. The average for the crayfish was 2.25 under this condition. The average, in the frog, was 1.25. For the snake it was 0. In the pigeon it was .55; in the rat, 1.14. The gross average for all situations and all animals under the condition, passive to tactual stimulation, was 1.03(as compared with .68 under light stimulation and .48 when the animal was passive in the dark.) It appears, then, that the animals, when passive, were, on the whole, least active in the dark, next active in room light or a special light stimulus, and more active still under a tactual stimulus. Again, the averages show a general reduction of brain activity as one ascends the animal scale. This is correlated with a reduction in the number of regions involved and the appearance of sharper gradients.

(3). Animal Active to Tactual Stimulation - (a) Animal Winced or Stiffened When Hit Leg or Back. In this situation the average magnitude, for the crayfish, was 3.15. The gradient shows maximum peaks in the visual, association, olfactory, and motor regions. The anterior (sensory) half of the brain is still slightly more active than the posterior half. In the frog

the average magnitude is 3.63. The gradient covers all regions with medium to maximum activity, with slightly more activity on the left side of the forebrain than on the right. In the snake the average magnitude was 2.21. There is a peak, in the gradient, in the olfactory and somatic region, while the olfactory, motor and visual regions are moderately active. In the pigeon, the average magnitude was 1.95. The gradient shows a peak in the anterior motor and olfactory regions, while the rest of the brain is almost homogeneous at a medium level of amplitude. The average magnitude in the rat, under this condition, was 1.52. The gradient, in this case, shows peaks in the auditory, somaesthetic and motor region, so that the general trend is anterior-lateral-posterior. It will be noted that, in the higher forms, a definite anterior-posterior gradient is developing, and that, at the same time there is a decrease in the average disturbance of the brain. In addition, differentiation is growing in a lateral direction. There is, therefore, in a shift from homogeneity to heterogeneity, the appearance of polarity, and a lateral region of increased sensitivity. The general average for all the animals in this situation, was 2.49 as compared with the average of 1.03 when the animal was passive to tactual stimulation.

(b). Animal Struggled, Wiggled or Raised Body when Hit or Punched Back, Pulled Tail, or Pulled Legs. In the crayfish the average magnitude, under this condition, was 2.62. It is significant that the peak of the gradient shifts from the anterior to the posterior or motor half of the brain. In the frog the average was 3.20. Most of the regions explored

now show maximum activity, but a definite medial-line gradient appears. (Situation (b) not available for the snake and pigeon.) In the rat the average magnitude is 1.66. The gradient is definitely anterior-posterior, with two maximum peaks, one in the motor and one in the auditory area. The similarity of this gradient with that found when the animal winced or stiffened (a) is obvious. The average for all the animals in this group is 2.49, which is the same as when the animal winced or stiffened, and compared favorably with the average of 1.03 found when the animal was passive to tactual stimulation. It will be noted, again, that the height of the activity decreases up the animal scale. It is greatest in the frog and crayfish, and least in the rat, while at the same time a more well defined gradient appears in the rat.

(c). Animal Winked When Its Eye Was Punched. All the animals are represented in this group except the snake and the crayfish. In the frog the average magnitude, when the right eye was punched, was 3.88. The brain was practically uniform in activity at a maximum level of amplitude. When the left eye was punched the average magnitude was 3.67. Again, the gradient is practically homogeneous, at a maximum level. In the pigeon, the average magnitude was 3.36. The general level for most of the brain was maximum under this condition, but a type of anterior-lateral-posterior gradient appears, which includes most of the motor region and only part of the visual. In the rat, the average magnitude was 2.27. In this case there is a small peak in the motor region, with a type of middle-medial-gradient, in which the rest of the cortex is

homogeneously active at a medium level. Still again there is a reduction of magnitude from lower to higher forms. In the lower forms the gradients are almost homogeneous at a maximum level. In the higher forms there is maximum disturbance in evidence of differentiation of the gradient into peaks. The average for all the animals under this condition was 3.29 as compared with 2.49 under struggling, wiggling, wincing and stiffening, and 1.03 with the animal passive to tactual stimulation.

(d). Winced Slightly When Rubbed Back or Stroked Body. Only two of the animal groups fall in this group. In the frog, the average magnitude was 3.00. Although the data are incomplete there are two anterior peaks, in the olfactory and motor regions. In the snake activity was 0. The average of the animal forms in this group is 1.50 as compared with 3.29 when the animal's eye was punched and 2.49 in the other situations in which the animal reacted to tactual stimuli.

(e). Average Active to Tactual Stimulation. With the crayfish active to tactual stimulation, the gross average was 2.88. The average for the frog was 3.47. For the snake it was 1.10; in the pigeon it was 2.65; and in the rat, 1.81. The gross average for all the situations where the animal responded to tactual stimulation was 2.38, as compared with 1.03 with the animals passive to tactual stimulation, .68 with light stimulation and .48 when the animals were passive in the dark. From the data on response to tactual stimulation it again appears clear that the higher the animal form the less the activity of the brain as measured by our experimental method.

At the same time, there appears in the higher forms a clearly defined gradient which, for the most part, is anterior-posterior in contour, as compared with the more homogeneous condition in the lower forms. Both these changes were found under passive to tactual stimulation. However, as opposed to the passive situation the level of the brain rises in both higher and lower forms as the animal responds to the tactual stimulus.

(4). Animal Active to Pain Stimulation - (a) Animal Struggled, Winced, or Stiffened When Legs, Back or Mouth Were Hit or Pinched. There were no stimuli which could be classed as painful in case of the crayfish. In the frog the average, under this condition, was 3.88. The brain is almost homogeneously active, over all areas, at a maximum level of amplitude. The average for the snake is 4.00. All of the regions studied are maximum in amplitude. These include the olfactory, motor and visual regions. In the pigeon the average was 2.74. A gradient appears which is posterior-lateral, with a middle band in the association region. Thus, the visual and somaesthetic areas are involved. The motor region is only moderately active. In the rat the average magnitude is 3.44. An anterior-medial-posterior type of gradient appears with peaks in the medial visual, motor and somaesthetic areas. Thus the shift in gradient from the pigeon to the rat suggests less use of the so-called auditory area and more of the somaesthetic and association areas, while both retain their anterior-posterior polerization. It will be noted that the tendency for the amount of activity to decrease in the higher animal forms is not as marked, now that

activity approaches a maximum, although there is a general trend downward, in the higher forms. At the same time, there is less homogeneity in the higher forms. The average for all the animals in this group is 3.51 as compared with 2.38 under active to tactual stimulation and 1.03 under passive to tactual stimulation.

(b). Animal Wriggled or Struggled When Pulled Tail or Punched Bill. The pigeon and the rat are the only two animal forms represented in this group. In the pigeon the average magnitude was 3.12. The gradient is posterior-lateral with a middle medial band in the association areas, as before. Parts of the visual and motor areas are only moderately active. The average magnitude in the case of the rat is 3.25. The gradient is anterior-medial in type, with a medial band from the visual region to the anterior motor region. The average for the animals in this group was 3.18 as compared with 3.51 under the other pain situation, 2.38 when the animals were active to tactual stimulation, and 1.03 when the animals were passive to tactual stimulation. A definite gradient again appears but at a higher level than under tactual stimulation. It is also significant that the somaesthetic and association regions increase in activity, under pain, in the higher animal forms, while under tactual stimulation the peaks were in the motor regions.

There is one situation in case of the frog which falls outside our other pain situation, namely, the animal struggling violently when HCl acid was placed on its skin. The average magnitude in this case was 4.0. The brain of the animal was

perfectly homogeneous, throughout at a maximum level of amplitude.

(c). Average Active to Pain Stimulation. The average for the frog was 3.94; for the snake, 4.00; for the pigeon, 2.93; and for the rat, 3.34. The gross average for all the animals under this situation was 3.55 as compared with 2.38 under active to tactual stimulation, 1.03 under passive to tactual stimulation, .68 under light, and .48 under darkness conditions. It can again be noted that the higher the animal form the less the activity of the brain. However, pain stimulation has caused a rise in the level of disturbance, at each step in the evolutionary scale. In the lower forms the brain is practically homogeneous at a maximum level of amplitude, while in the higher forms, clearly defined gradients appear, usually of a posterior-lateral-anterior type. It is significant that, in the pigeon and in the rat, the association and somaesthetic regions are relatively more involved than the motor region which was not the case during motor activity to tactual stimulation where motor regions were relatively more active.

(5). Spontaneous Activity. (a). Animal Struggling, Wriggling or Walking. In the crayfish the average magnitude was 1.61. A diagonal gradient appears from the visual-and-olfactory regions to the association-and-motor regions. The fact that less activity occurred in this case, than under tactual stimulation, suggests that the tactual stimulus was painful, and is born out, perhaps, by the dominance of the sensory areas in the maps obtained under tactual stimulation. In the

frog, the average was 3.66. The gradient shows a posterior peak in the thalamus, which tapers off gradually anteriorally, but steeply posteriorally. In the snake the average was 4.00. The data are insufficient, in this case, but show maximum activity even in the olfactory region. In the pigeon the average was 3.00. The gradient is definitely lateral and slightly posterior, so that part of the visual, association and motor regions are involved. The average magnitude in the rat was 3.50 The gradient is anterior-posterior in type. The average for all the animals under this condition was 3.15, as compared with 2.38 under active to tactual stimulation and 3.55 under active to pain stimulation. The amount of activity now increases in the higher over the lower forms. This is particularly true when we compare the crayfish with the pigeon and rat, but is less true between the crayfish and the frog. That the general trend should be an increase in activity of the brain in the higher form under spontaneous activity and a decrease under pain and tactual stimulation is probably a significant index to the general problem of comparative functional neurology. Greater differentiation means greater spontaneity of action.

There is one situation in the rat which does not come under the above group, in which the animal was spontaneously biting, swallowing, jittering, or breathing very hard. The average under this condition is 2.80 as compared with 1.81 under active to tactual stimulation and 3.34 under active to pain stimulation. The gradient is anterior-posterior in type with a lateral band, so that maximum active regions include the visual, auditory, somaesthetic, and the forward part of the motor region. The

average of 2.80 is less than the 3.15 when the animal was struggling spontaneously, a fact in keeping with the much less activity in the former situation.

(b). Average Spontaneous Activity. The average for the crayfish, under spontaneous activity, was 1.61; in the frog it was 3.66; in the snake it was 4.00; in the pigeon, 3.00; and the rat, 3.15. The gross average for all the animals was 3.08 as compared with 3.55 under pain, 2.38 under active to tactual stimulation, 1.03 under passive to tactual stimulation, .68 under light, and .48 with the animal passive in the dark. Again the higher the animal form the more active the brain under spontaneous movement, as compared with a decrease under pain and tactual stimulation. The fact that the frog shows nearly the activity of the pigeon may relate to its motility. Again a greater differentiation of the animal's brain seems to be coincident with greater spontaneity of action.

(6). Active to Tactual-and-Visual Stimulation - There is only one animal represented in this group, the pigeon. It jumped when the experimenter blew at its head or waved his arm. The average magnitude is 3.42, as compared with the gross average of 3.08 under spontaneous activity, 3.55 under pain, 2.38 under active to motor stimulation, 1.03 under passive to motor stimulation, .68 under light, and .48 with the animal passive in the dark. The gradient is of a definite posterior and lateral type, with a maximum level in all the visual regions, and the suggestions of an anterior pole in the motor region. This result suggests that in the higher animal forms, with a relatively differentiated visual system, such a stimulus as this proves more effective than a tac-

tual or pain stimulus. Our conclusion is substantiated by the fact that all of the visual regions are highly active under this condition.

(7). Auditory Stimulation - (a) Passive to Sound Stimulation. In the crayfish the average magnitude was 2.91. The brain shows activity with peaks in the visual and olfactory regions similar to the type which occurred under light stimulation. In the frog it was 1.41. The peaks of activity occur in the auditory, visual and olfactory regions. The average magnitude in the snake was .66. The peak in this case is located in the anterior olfactory region. In the pigeon the average was 1.00. The gradient shows a definite middle-lateral peak, which coincides with the auditory region in higher animals. The visual and motor regions are very slightly active. In the rat the average was .67. The gradient is of an anterior-posterior type. The auditory, somaesthetic, and part of the visual region are only slightly active. There is a definite reduction in activity under sound stimulation in the higher animal as compared with the lower, agreeing with facts already noted. The visual and to some extent the motor regions are the areas which decrease in activity. This is consistent with the reduction of activity found in the visual area, in the higher forms, under room stimulation. The gross average for all the animals, under this condition of sound stimulation, is 1.33 as compared with .48 under darkness, .68 under light, 1.03 under passive to tactual stimulation, 2.38 under active to tactual stimulation, 3.55 under active to pain stimulation and 3.08 with spontaneous activity of the animal.

(b). Animal Jumped, Winced, Blinked or Walked Under Sound Stimulation. The frog and the snake are not represented in this group. In the crayfish the average was 1.50, There is a gradient which extends from the sensory portion of the brain to the posterior portion which has a motor function. In the pigeon the average response to the quincke tube was 1.51, while to the tuning fork it was 2.10. With the quincke tube the gradient is anterior-lateral-posterior, with peaks in the motor regions, while the visual region has taken on more activity than when the animal was passive. In the case of the tuning fork the gradient is definitely anterior-lateral, involving the motor and auditory regions, while the visual region is less active. In the rat the average is 1.76. In this case the line of the gradient is middle-medial with the auditory, visual, and somaesthetic regions moderately active. There is a high peak in the motor region. The gross average for all the animals under this condition is 1.68, as compared with 1.33 when the animal was passive to sound. It will be noted that the various animals' brains are more nearly alike dynamically, under activity to sound stimulation, than under other conditions, since the motor and visual regions come into play in both the higher and lower animal forms. This must mean that, when the animal responds to sound, the activity is scattered throughout the brain, but peaks predominate in the auditory and now the motor regions. It will also be noted that the brains of the higher animals become more active, but that those of the lower become slightly less active. In both, how-

ever, the activity extends to the motor region at the expense, probably, of high activity in the sensory areas.

(c). Average Sound Stimulation. In the crayfish the average under sound was 2.44. The magnitude under sound conditions was only exceeded by that under active to tactual stimulation. In the frog the average was 1.41. In this case the magnitude under sound exceeded all of the other passive situations. The average magnitude in the snake was .66. Again the magnitude under sound exceeded all the other passive conditions. In the pigeon the average was 1.53, which exceeds all other passive situations. In the rat the average was 1.21, in this case also, it is greater than for the other passive situations. Once more there is a general reduction of activity in the higher animal forms, as compared with the lower, which is more marked when the animal is passive than when active. This reduction, it was noted, took place largely in the visual and motor regions. In the higher animal forms a more definite auditory gradient appears, which however, extends to motor and visual areas when the animal responds to the sound stimulus by making movement.

The average for all the animals under sound stimulation is 1.45, as compared with .48 under darkness, .68 under light stimulation, 1.03 when the animal was passive to tactual stimulation, 2.38 when active to tactual stimulation, 3.55 when active to pain stimulation, and 3.08 with spontaneous activity of the animal. Thus it can be said that on the average the animal's brain is more active under sound stimulation than under darkness, light or tactual stimulation with the animal passive. Next in activity comes the situation when the animals

were active to tactual stimulation, which is exceeded when they make spontaneous movements. The greatest cortical disturbance, on the average, occurs when the animals are active under pain stimulation.

IX. CONCLUSIONS.

(1). Conclusions on Gradient Distribution. In all the animal forms and under all the diverse conditions of stimulation, brain activity was characterized by gradients. That the brain should exhibit activity in the form of gradients, in the crayfish, frog, snake, pigeon and rat, is consistent with the studies of Bartley (6) and Perkins (30) in which gradients appeared in the cortex of the dog under all stimulus conditions. In general an energy distribution differentiated in the form of a pattern or gradient seems to be consistent with the observed facts of behavior. Child (14) was the first investigator to show the applicability of the gradient theory to physiological growth and Coghill (15) was quick to follow with evidence from embryology that the field conception was demanded by data on the organism's first movements. Wheeler (35, 36, 37) has shown how the gradient theory can be applied to mental as well as to physiological development. The fact, then, that a gradient appears in all brains in all the animal forms in all behavior situations points indisputably to a field concept of neural functions rather than to a theory based on inherent properties of isolated structures. Previously, in the rat, Lashley (27) had shown, by the extirpation method, that a certain percentage of brain tissue must be present for a given function and the more differentiated the function the greater the mass necessary. He proposed a theory of mass action as the basis of neural function. The mass theory is the forerunner of the gradient or field theory.

A field or gradient theory of brain activity is not only supported by the facts of this investigation. They permit a more refined statement of the theory, as it applies to single brains, and suggests certain principles pertaining to the differentiation of the brain in the animal scale. First, in the forms studied, particularly in those rather low in the animal scale, there was a noticeable diversity in gradients even under similar or nearly similar stimulation. This seems to mean that, in the lower forms, the various structural units are more equipotential. This, again, correlates well with the work of Lashley (27) in which he proposed, from his study of the rat, a theory of equipotentiality, namely, that the various areas of the brain are equally capable of carrying on a given function providing a certain critical mass of the brain tissue is present. It would mean in this case, that, under nearly the same stimulus conditions, the gradient would be more likely to undergo a change in contour than in higher forms like the dog. This interpretation is further supported by neurological investigations of the lower forms. In connection with the inner structure of the frog's brain Herrick (24, p. 281) remarks that the equipotential structure of the brain "obviously favors total reactions or mass reflexes". Kappers (26) comments that, in the avian, a large portion of the forebrain is to be regarded as 'vicarious'. Huber and Crosby (25, p. 178-9) say that all structural factors "tend to diminish the possibilities of definite localization and relative independence of the forebrain centers". All of these statements are borne out by our results. The gradients of the

simpler brains were not confined to, or stabilized in, any definite anatomical region. In fact the contour of the gradient, in keeping with the equipotentiality of the structural relations, appears to vary with chance.

Second, in the higher forms, there appears a posterior-anterior type of gradient when the animal is active to stimulation. This confirms the results of Bartley (6) and Perkins (30) on the dog in which this tendency was very pronounced. It would seem that the activity in the visual region is related to the fact that the animal is trying to free itself or remove the motor stimulus. That the gradient should show a peak not only in the motor region but in the visual region under these conditions is further proof of the gradient and field theory as opposed to a localization of function theory. A conclusion of this sort is unavoidable in face of the fact that the visual area undergoes maximum disturbance even in the dark.

Third, a greater homogeneity of function is found in the lower forms. In many cases the lines of the gradient definitely disappeared. This fact is consistent with the findings of Lashley, Kappers, Herrick and others, cited above, that, in lower forms, the brain becomes more equipotential. This means that a given stimulus will affect a wider area with setting up a differentiated gradient. Homogeneity also suggests less density and resistance to spreading of the disturbance from its source of entry into the brain. Therefore, we might expect more widespread affects as a consequence of a given stimulus, in the lower than in the higher brains. This is exactly what we did

find. The lower the animal form the wider the area involved and at the same time the more homogeneous the disturbance. As the animal brain differentiates it takes on greater specialization of function observable in sharper and more distinctly outlined gradients of activity, under all conditions, but the mass is still involved in the higher forms.

Fourth, when a tactual stimulus was given and the animal moved, the motor region was involved, particularly in the higher forms. However, when a pain stimulus was given the sensory areas became relatively more active, particularly the visual, auditory, and somaesthetic. This is consistent with the obvious fact that, in pain, the animal attempts more vigorously to organize its reactions with respect to sensory stimulus situations.

Fifth, under auditory stimulation, a lateral type of gradient occurred in the more differentiated animal forms. In the lower forms, the association or olfactory regions were active, which is probably related to the differentiated 'olfactory' character of the animal's brain. It would appear that those sensory areas which are most highly differentiated are brought into play, in response to sensory stimulation, regardless of the mode of stimulus. It is not unreasonable to suppose that the lower forms "hear" with energy available in the 'olfactory' regions. The fact of a gradient with a lateral peak in the auditory region in the pigeon and rat is consistent with the results which Perkins (31) found on the dog. In the case of the dog, however, this lateral gradient was more constant, and more marked, which agrees with the greater flexibility of gradient formation already found in

the lower animal forms. When the animal reacted to the sound with movements a peak appeared also in the motor region. This was found true for the dog by Perkins (31).

Sixth, in the more differentiated animal brains a gradient headed in the posterior region appears under light stimulation. This agrees with the work of Bartley (6) in which a similar gradient was shown in the dog. Again, however, the gradients in the present cases were not as stable as in the dog, due to the more fluid and homogeneous nature of the brain. Lashley (27) found, in the rat, that visual discrimination of a complex type, such as form, disappeared with destruction of the visual region, but that within the visual region an equipotentiality of tissue remained. In case of a less highly differentiated visual response like that to brightness stimulation the entire brain was equipotential within the limits of a given maximum of the total brain tissue. Our results are consistent with these of Lashley in showing a flexible gradient formation for vision in the lower forms.

Bartley and Bishop (11) have shown, with the Cathode Ray oscillograph, a fairly clearly localized response in the optic cortex of the rabbit under an anaesthetic, but at the same time have shown that the magnitude and presumably the region of the response is directly correlated with the depth of the anaesthetic. This would mean that, with electrical stimulation of the optic nerve, and the animal is under an anaesthetic, the visual gradient is limited and at the same time, decreased in amplitude. Hartline and Graham (22) and Adrian (5) have shown that a single optic fibre responds to light stimulation through the retina, by dis-

charging in volleys. This is presumably related to the fact that the retina is, genetically, brain tissue separated off during embryonic development. It would mean, further, that the activity of the central nervous system, initiated by a visual stimulus, should give a multiple, complex type of record. This is just the type of record we obtained.

(2). Conclusions on Magnitude of Brain Distrubance. There are certain important points to be discussed in connection with the magnitude of cortical disturbance. First, in all behavior situations the magnitude of cortical disturbance decreases in the higher animal forms. This fact seems related to the greater mass of forebrain found in the latter. Bishop and Bartley (8) showed that if a peripheral nerve was laid over the surface of the rabbit's cortex, and stimulated, the action current from the nerve was reduced to 6 per cent of what it was when not touching the cortex, while if it was threaded through the cortical tissue the response could be reduced to 1 per cent, depending on the depth into the tissue. This would indicate, applied to our results, that the greater the mass of the tissue the greater the 'shunting' and therefore the smaller the amplitude of the activity recorded on the surface in a given behavior situation. This 'shunting' is probably related to the spontaneous activity of the cortex which goes on at all times. This spontaneous activity was shown to exist by Bishop and Bartley (11), Adrian and Buytendijk (3). Adrian showed that spontaneous activity could be recorded from the isolated brain of the goldfish. The 'quiet' records in the present investigation always showed

slight spontaneous activity. The greater the mass and differentiation of cortical tissue the more sharp the gradient formation induced by stimulation. The resultant of force between existing cortical energy and the energy of incoming conduction will constitute a kinetic distrubance of less amplitude.

Recall that Bartley and Bishop (8) found the level of amplitude of the brain action currents decreased under an anaesthetic. There is a possible alternate conclusion to be offered, therefore, for at least part of the reduction in amplitude as we ascend the animal scale. The higher animals had been under an anaesthetic while the lower animals had not. We are inclined, however, to discredit the second conclusion, since the animal was given 45 minutes or an hour in which to recover, before recording began. Furthermore, the increase in spontaneous activity, as we ascend the scale, militates against the anaesthetic theory.

A third factor, probably related to the decrease in amplitude in the higher animal forms, is the greater structurization of the brain. This would mean a greater lag or resistance to conduction. Thus the greater the structurization the less able the brain to reach a high potential under stimulation from outside due to permanent maturation with respect to particular stimulus situations. A dynamic theory would predict that this structurization would lead to increased possibilities of spontaneous activity, and this is what we found. In the lower forms the high degree

of structurization cannot take place and thus the brain, in these forms, under a given stimulation, attains a higher energy level and much the same level for a large variety of stimuli. Thus, cortical evolution may be described as the achievement of that differentiation of structure which protects the brain against the more excessive, and also more homogeneous expenditure of energy found in the lower brains. 'Progress' comes with means of conservation!

Second, our investigation shows that the only situation in which the amount of amplitude increased, through the various animal forms, was spontaneous activity of the animal. Bartley (6) found, in the dog, that a maximum level of amplitude occurred under this condition. This must mean that, as the brain differentiates, those same patterns of energy which become more structured from the standpoint of a disturbance impinging from outside, function for increased spontaneous response. From the standpoint of intensity, the large brain mass in the higher animals is more significant for aggressiveness of the animal than for fine degrees of sensory discrimination. It is the former that requires the larger source of energy. (Cf. Lashley (27) for the behavior of rats and monkeys after extirpation. They 'fatigued' more readily, and in general showed less 'persistance'. One aspect of evolutionary development, then, is obviously greater 'spontaneity' of action. It might be conjectured that this 'spontaneity' of brain action, in the highly differentiated human form is the neural background of creative thought.

Third, facts are available to relate spontaneous activity to the more simple form, the so-called reflex. In the case of the eyelid 'reflex' it was noted, in the lower forms, that the brain was involved throughout at a maximum level of magnitude, while in the case of more voluntary activity in these the activity was much lower. These facts can be interpreted in light of our remarks on 'spontaneous' activity. In the less differentiated brain, with its less highly structured parts, a simple response like the eyelid 'reflex', involves the brain homogeneously. Simplicity of control means widespread homogeneity of control under laws of dynamics. The picture is the reverse of the conventional view of simple reflex action in the intact animal. (These results are consistent with the findings of Magmus (39) on posture.) To set up a differential of activity in the complex brain, for purposes of the simple reflex means a greater expenditure of energy and more effort and delay in the corresponding response. In the lower animal forms, the homogeneous brain can accomplish this more easily due to its undifferentiated structure and lack of resistance to peripheral processes. The greater ease is demonstrated, not by a low level of action current, but by a higher one, since the brain as a whole, in the intact animal, produces the reflex. In the higher animal forms, the picture was different as regards the eyelid response, due to the differentiated structure which offered resistance and shunting to the peripheral process. There could not be a homogeneous brain response at so high an energy level. Instead, a higher con-

centration of energy in the more local and highly differentiated nerve structures, figured on a total cortical ground, produced the movement. It was therefore not recordable from more remote regions.

In voluntary or spontaneous activity in the higher forms, differentials will appear, and the amplitude level will be higher because of energy already available in the cortex.

The fact that a simple response like the eyelid reflex could be recorded from all regions in the lower forms, and at a maximum level of amplitude, is consistent with the findings of Travis and Herren (34) on the rat. These investigators demonstrated that, in the Achilles reflex, actions currents could be recorded from all parts of the central nervous system. In a further study, Travis and Fossler (33) demonstrated that, in the Achilles reflex, the electrical response consistently appeared in both halves of the cord. Evidently the spreading which occurred over the entire brain, in this study, in the frog is also found in the cord. These facts unquestionably refute a pathway or simple reflex arc theory of reflex action.

Fourth, in comparing the animal forms and the behavior situations, it was found, that, when the animal was active to pain, the greatest magnitude of brain disturbance occurred. In the higher forms there occurred an extension of high activity to the sensory areas, thus reducing the relative predominance of the anterior pole. Recent studies by Adrian (4) on the electrical response in the peripheral nervous system under pain stimulation, shows that a slow frequency and low

amplitude series of impulses occurs under pain; slow and fast, irregular, throws occur under temperature; and high amplitude throws occur under pressure stimulation. This must mean that a slow frequency, and low amplitude peripheral disturbance produces a greater effect upon the central nervous system than a high frequency, high amplitude peripheral process. This difference ties up with the shunting effect of the central system, in that the high frequency process is the one shunted out. The high frequency, perhaps, has a mean amplitude and frequency more nearly coinciding with the spontaneous activity going on in the brain, whereas the slow frequency input, differing more widely from the spontaneous activity of the central system, does not suffer so much from the process of forming a resultant between the two. If a recordable cortical response is to occur, under laws of field structure, it would seem reasonable to assume that it is the consequence of an unresolved differential. Where field and incoming energy are more nearly alike there is less differential, and therefore a lesser adjustment for the cortex to make.

Fifth, in the higher forms, the activity of the brain increased under darkness conditions to the extent that, in the rat, it exceeded in magnitude, the activity occurring under light stimulation. In the lower animal forms the room light condition gave a definite response, which seemed to disappear in the higher forms. This probably means that, in the more developed animal forms, a type of adaptation has occurred to the constant illumination of the room. Moreover, in terms of

dynamic theory again, adaptation requires the possibility of a change in adjustment, and this in return, requires differentiated field structure. The lower forms, lacking this field structure, exhibit less 'adaptation'. This is what we found. Adaptation means contrast. When the darkness was introduced, in the lower forms, there was a cutting down of brain activity since the visual stimulus was removed. In the higher forms the introduction of the darkness condition produced more activity in the brain, since the stimulus to which the animal was adapted had been removed and a new stimulus condition introduced to which the animal was not adapted, obviously cortical evidence of contrast. In the case of the pigeon, activity appeared in the visual region under darkness, while in the rat the visual and auditory regions were involved. It might be concluded that the higher the animal form, the more the cortical effect. This effect is interpreted in a broad sense to mean 'general cortical disturbance', and might well include energy involved in 'surprise', 'effort to see and hear', 'readiness' for 'protection', and even the functioning of 'imagery'. All of this harmonizes with the general fact, already noted, that a predominant function of the higher cortex is that of initiating activity.

Sixth, and finally, the conclusion, suggested by Bartley (6), that different parts of the brain may subserve different functions at different times, in accordance with the adjustment demanded of the cortex as a whole, is seemingly confirmed. This is not inconsistent with the possibility that areas

like the auditory and visual, structured, obviously, with respect to auditory and visual situations, are contributing energy to 'efforts' to see and hear, although specific stimuli are lacking. This fact is evident from our results which show lower amplitude in these regions, when under direct stimulation, than when under the conditions of motor activity with no direct stimulation. It is, therefore, almost mandatory to assume that energy in the sensory cortex has 'motor' as well as 'sensory' function. It is required, under field laws, to 'help move' the animal.

X. SUMMARY.

This investigation of five different brains (crayfish, frog, snake, pigeon, and rat) by the action current technique, following the method of Bartley (6), Newman (29) and Perkins (31) yields, in brief, the following results.

(1). A total of 1195 separate records were obtained under an average of seven groups of stimulus-and-behavior situations.

(2). In general, earlier work disproving the localization of function, or mosaic theory, of brain activity is confirmed, and a dynamic, gradient, or field-structure theory, is at all points substantiated and supplemented.

(3). There is demonstrated a shift from homogeneity of condition toward greater heterogeneity, as one ascends the animal scale. The greater homogeneity is characterized by the absence of gross differentials, by gradients only slightly polarized, by greater disturbance to stimulation, less difference between the condition of sensory stimulation and spontaneous activity, by less evidence of 'adaptation' and its dynamic opposite, 'contrast', by less disturbance in spontaneous activity, by a relatively greater amplitude of transneural activity in the production of the simple reflex, and by an approach to a chance location of a given local disturbance.

(4). The greater heterogeneity of the higher brain is characterized by the invariable presence of gradients, by gradients of sharper contour and more stable form, by in-

creased polarization, by less measurable disturbance to peripheral stimulation, by a far greater difference between the cortical picture during response to specific stimulation and voluntarily initiated activity, by greater activity under the condition of spontaneous movement, by more evidence of cortical 'adaptation' and 'contrast', by less widespread or intensive disturbance in the production of the so-called 'simple reflex', and by a more predictable appearance of gradient peaks.

(5) A dynamic theory, calculated to throw light upon these phenomenon, is presented in each case.

(6). The increased cortical disturbance found in connection with pain stimulation is brought into relation with recent findings of Adrian, and are given a dynamic interpretation.

(7). A dynamic interpretation, as opposed to a specificity of function theory, is placed upon the result confirming Bartley, that various parts of the cortex seem to have more than one function, dependent upon the conditions of stimulation at the time, and upon what behavior the animal is attempting to carry out.

(8). In general, the results support an organismic interpretation of neural functioning, as set forth, previously, by Bartley, Newman, Perkins, Child, Coghill, Lashley and Wheeler.

XI. BIBLIOGRAPHY

1. Adrian, E. D. 1928. The basis of sensation. Norton.

2. Adrian, E. D., and Zotterman, Y. 1926. The impulses produced by sensory nerve-endings. Part 2 The response of a single end-organ. Jour. Physiol., 61, 151.

3. Adrian, E. D., and Buytendijk, F. J. J. 1931. Potential changes in the isolated brain of the goldfish. Jour. Physiol., 71, 121.

4. Adrian, E. D. 1932. The mechanism of nervous action; electrical studies of the neurone. University of Pennsylvania Press.

5. Adrian, E. D. 1932. The activity of the optic ganglion of dytiscus marginalis. Jour. Physiol. 75, p. 26.

6. Bartley, S. H. 1931. Gross differential activity of the dog's cortex as revealed by action currents. Dissertation, University of Kansas. Also 1933, Psych. Mono. 44, 30.

7. Bartley, S. H., and Newman, E. B. 1931. Studies on the dog's cortex. 1. The sensori-motor areas. Amer. Jour. Physiol., 99, 1.

8. Bartley, S. H., and Bishop, G. H. 1932. Cortical response to stimulation of the optic nerve. Proc. Soc. Exp. Biol. and Medicine, 29, 775.

9. Bartley, S. H. 1933. Action potentials of the optic cortex under the influence of strychnine. Amer. Jour. Physiol., 103, 203.

10. Bartley, S. H., and Bishop, G. H. 1933. Factors determining the form of the electrical response from the optic cortex of the rabbit. Amer. Jour. Physiol., 103, 173.

11. Bartley, S. H., and Bishop, G. H. 1933. The cortical response to stimulation of the optic nerve of the rabbit. Amer. Jour. Physiol., 103, 159.

12. Bishop, G. H., and Bartley, S. H. 1932. Electrical activity of the cerebral cortex as compared to the action potential of excised nerve. Proc. Soc. Exp. Biol. and Medicine, 29, 698.

13. Bishop, G. H. 1933. Cyclic changes in excitability of the optic pathway of the rabbit. Amer. Jour. Physiol., 103, 213.

14. Child, C. M. 1924. Physiological foundations of behavior. Holt.

15. Coghill, G. E. 1929. Anatomy and the problem of behavior. Macmillan.

16. Droogleever Fortuyn, E. B. 1914. Cortical cell-lamination of the hemispheres of some rodents. Arch. Neurol. and Psychiat., Path. Lab., London, 6, 221.

17. Gasser, H. S., and Erlanger, J. 1922. A study of action currents of nerve with the cathode ray oscillograph. Amer. Jour. Physiol., 62, 496.

18. Gasser, H. S., and Erlanger, J. 1925. The nature of conduction of an impulse in the relatively refractory period. Amer. Jour. Physiol., 73, 613.

19. Gurdjian, E. S. 1927. The deincephalon of the albino rat. Studies in the brain of the rat. No. 2. Jour. Comp. Neur., 43, 1.

20. Hanström, B. 1925. The olfactory centers in Crustacenas. Jour. Comp. Neur., 38, 221.

21. Hanstrom, B. 1928. Vergleichende Anatomie des Nervensystems der Wirbellosen Tiere unter Berücksichtigung seiner Funktion. Berlin.

22. Hartline, H. K., and Graham, C. H. 1932. Nerve impulses from single receptors in the eye. Jour. Cellular and Comp. Physiol. 1, 277.

23. Herrick, C. J. 1925. The amphibian Forebrain. III. The optic tracts and centers of Amblystoma and the frog. Jour. Comp. Neur., 39, 433.

24. Herrick, C. J. 1927. The amphibian forebrain. IV. The cerebral hemispheres of Amblystoma. Jour. Comp. Neur., 43, 231.

25. Huber, G. C., and Crosby, E. C. 1929. The nuclei and fiber paths of the avian diencephalon, with consideration of telencephalic and certain mesencephalic centers and connections. Jour. Comp. Neur., 48, 1.

26. Kappers, C. U. A., and Droogleever Fortuyn, E. B., 1920. Vergleichende Anatomie des Nervensystems. Haarlem.

27. Lashley, K. S. 1929. Brain mechanisms and intelligence. Univ. of Chicago Press.

28. Muskens, L. J. J. 1929. The tracts and centers in the pigeon dominating the associated movements of the eyes (and other movable parts) in the sense of lateral deviation in the horizontal and of rotation in the frontal plane. Jour. Comp. Neur., 48, 267.

29. Newman, E. B., 1930. A functional study of the cerebral cortex by means of recording action currents. Master's Dissertation, University of Kansas.

30. Papez, J. W., 1929. Comparative Neurology. Crowell.

31. Perkins, F. T. 1931. A study of cerebral action currents under sound stimulation. Master's Dissertation, University of Kansas. See also 1933, Psych. Mono. 44, 1.

32. Taft, R. 1930. A convenient system of water thermostats for laboratory instruction. Jour. Chem. Educ. 7, 2053.

33. Travis, L. E., and Fossler, H. R. 1931. An electrophysiological study of the 'simple' reflex circuit. Proc. Soc. Exp. Biol. and Medicine, 28, 1043.

34. Travis, L. E., and Herren, R. Y. 1931. The relation of electrical changes in the brain to reflex activity. Jour. Comp. Psychol., 12, 23.

35. Wheeler, R. H., 1929. The Science of Psychology. Crowell.

36. Wheeler, R. H., 1930. Readings in Psychology. Crowell.

37. Wheeler, R. H., and Perkins, F. T. 1932. Principles of Mental Development. Crowell.

38. Kalischer, O. 1905. Das Grosshirn der Papageien in anatomischer und physiologischer Bezeihung. Abhandl. der K. Preuss. Akad. der Wissensch. Berlin. Abn. 4, 1.

39. Magnus, R. 1925. Animal posture. Proc. Roy. Soc. (B), 98, 335.