Stéréotaxie & Neurophysiologie

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Laboratoire de Physiologie

Faculté de Médecine Pierre et Marie Curie

novembre 2005

Stéréotaxie & Neurophysiologie

- Horsley et Clarke (1908)
- Stephen W. Ranson (1930)

<u>Méthode stéréotaxique</u>

- barres d'oreilles; coordonnées spatiales;
- Insertion d'électrodes dans le cerveau
- Stimulations
- Enregistrements
- Identification anatomique des structures profondes

A STEREOTAXIC ATLAS OF THE CAT BRAIN

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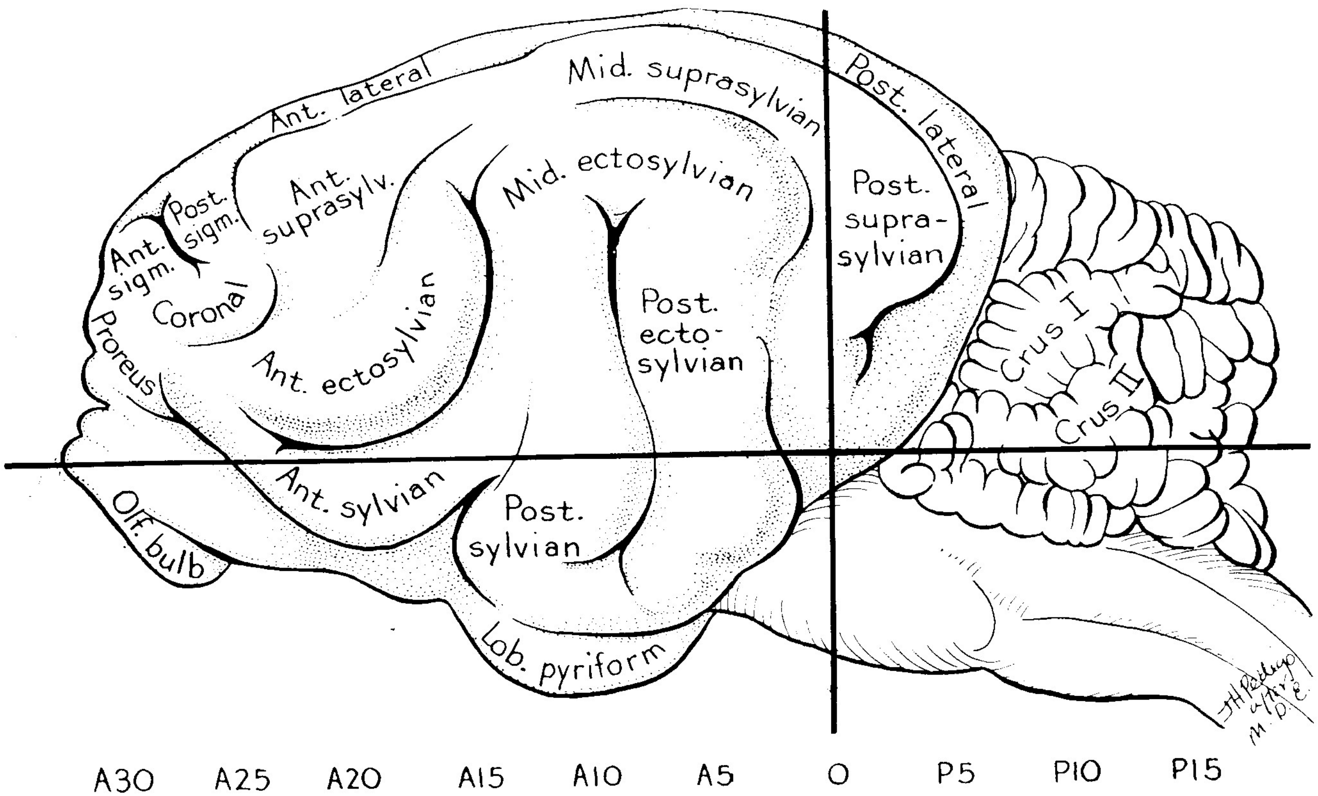
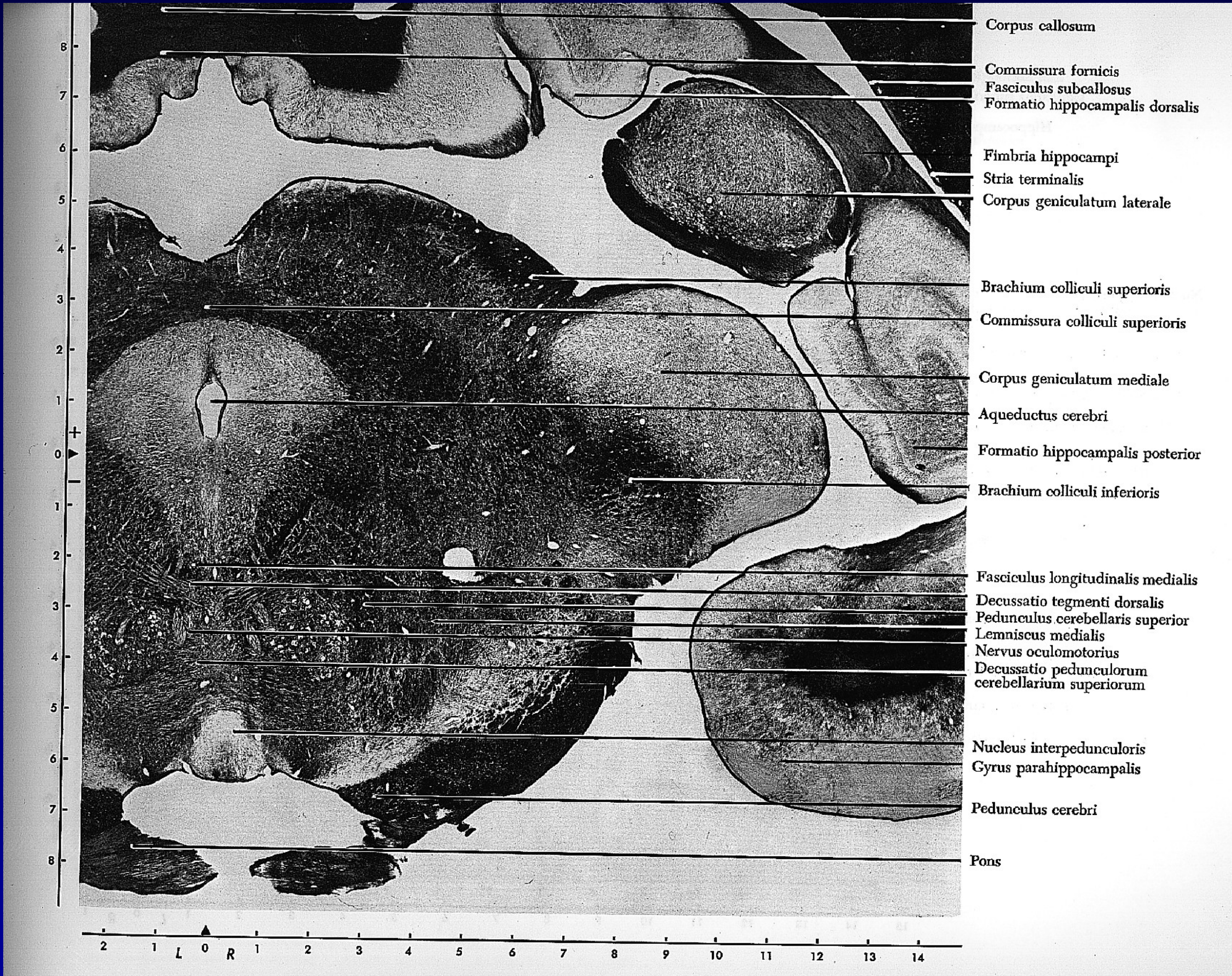
CREIGHTON UNIVERSITY MEDICAL SCHOOL

THE UNIVERSITY OF CHICAGO PRESS



Schematic diagram of the cat brain showing major gyri, with some intentional distortion at the superior surface for purposes of display.

The successive plates are cross-sections of the cat brain at 0.5-mm. intervals. The horizontal line shown here indicates the zero position on the

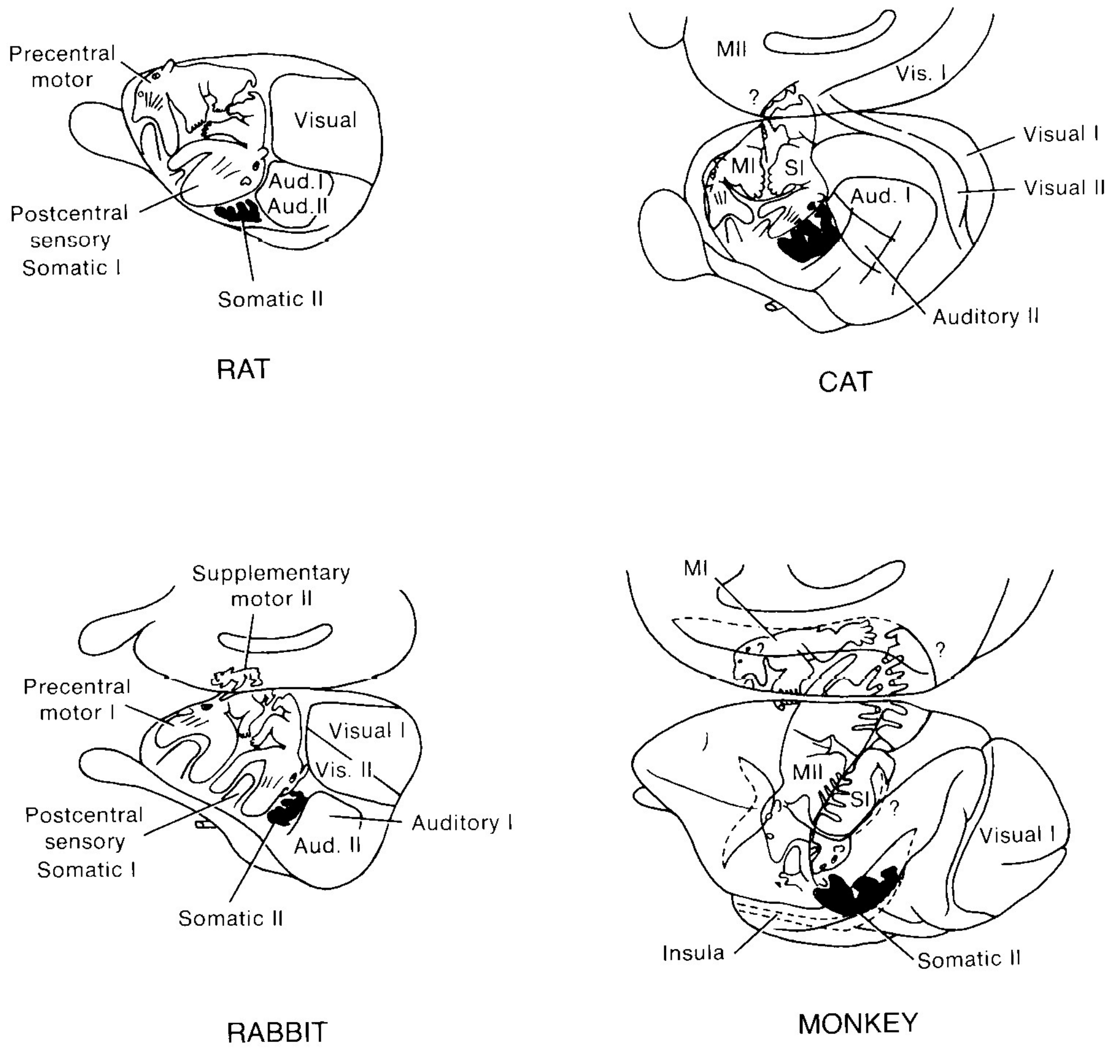

Corpus callosum
Commissura fornicis
Fasciculus subcallosus
Formatio hippocampalis dorsalis
Fimbria hippocampi
Stria terminalis
Corpus geniculatum laterale
Brachium colliculi superioris
Commissura colliculi superioris
Corpus geniculatum mediale
Aqueductus cerebri
Formatio hippocampalis posterior
Brachium colliculi inferioris
Fasciculus longitudinalis medialis
Decussatio tegmenti dorsalis
Pedunculus cerebellaris superior
Lemniscus medialis
Nervus oculomotorius
Decussatio pedunculorum cerebellarium superiorum
Nucleus interpeduncularis
Gyrus parahippocampalis
Pedunculus cerebri
Pons
8 7 6 5 4 3 2 1 + 0 − 1 2 3 4 5 6 7 8
2 1 L 0 R 1 2 3 4 5 6 7 8 9 10 11 12 13 14

Somesthésie

• Wade Marshall, Clinton Woolsey, Philippe Bard (1938 -1941) - potentiels évoqués : organisation somatotopique du cortex pariétal; cartes distordues

• Vernon Mountcastle (1952), Jerzy Rose –
- enregistrement cellulaire : neurone central = champ récepteur spécifique
- organisation en colonnes à modalités spécifiques

• Woolsey; Killackey; Welker; Vanderloos : plasticité et développement chez les rongeurs

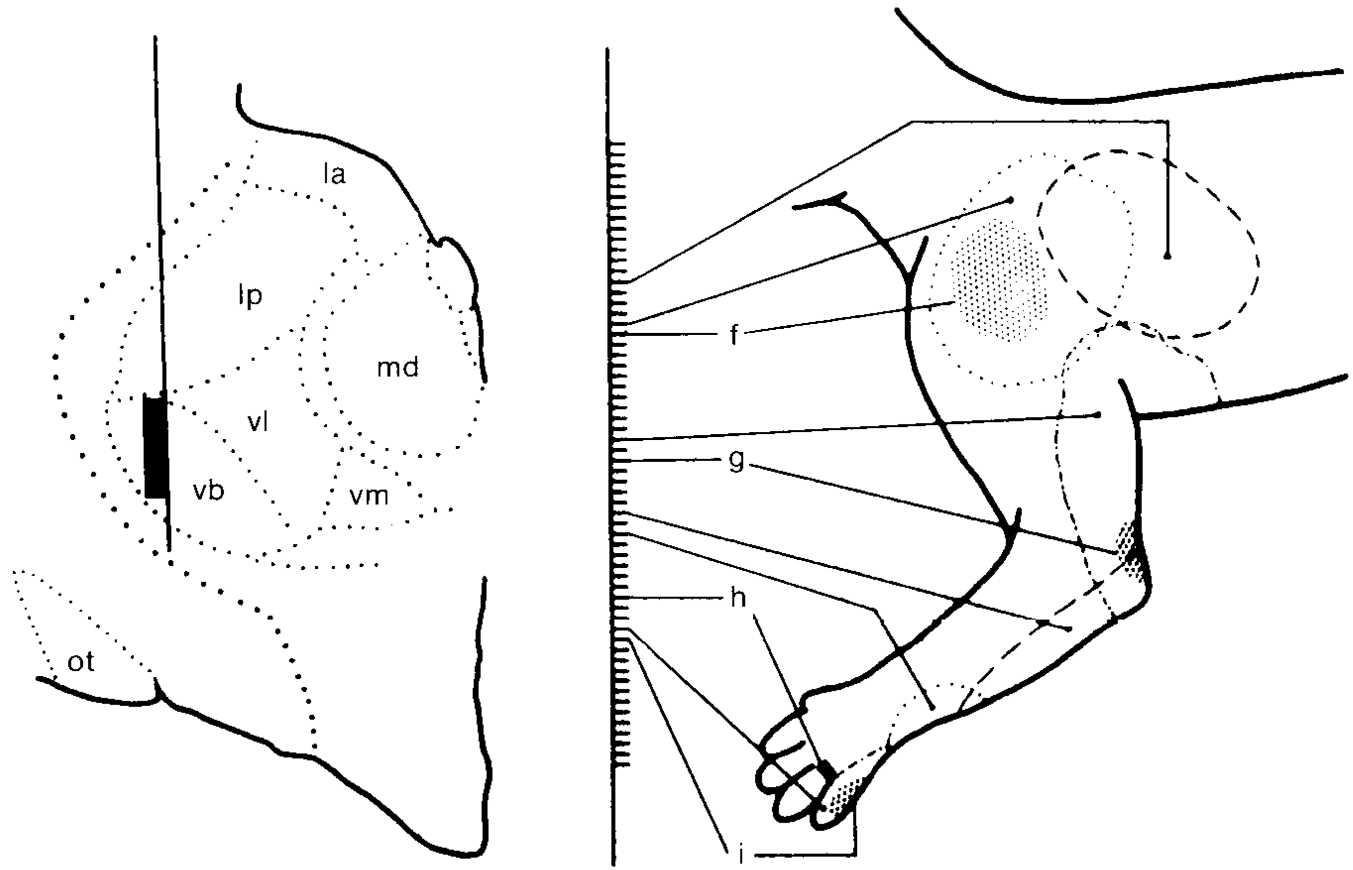


Precentral motor
Visual
Aud. I
Aud. II
Postcentral sensory Somatic I
Somatic II
RAT
MII
Vis. I
?
MI
SI
Visual I
Visual II
Aud. I
Auditory II
CAT
Supplementary motor II
Precentral motor I
Visual I
Vis. II
Postcentral sensory Somatic I
Auditory I
Aud. II
Somatic II
RABBIT
MI
?
MII
SI
Visual I
Insula
Somatic II
MONKEY

Relais sensitifs thalamiques

Réponses du noyau Ventral Postérieur :

- champs récepteurs étroits
- unités rapides

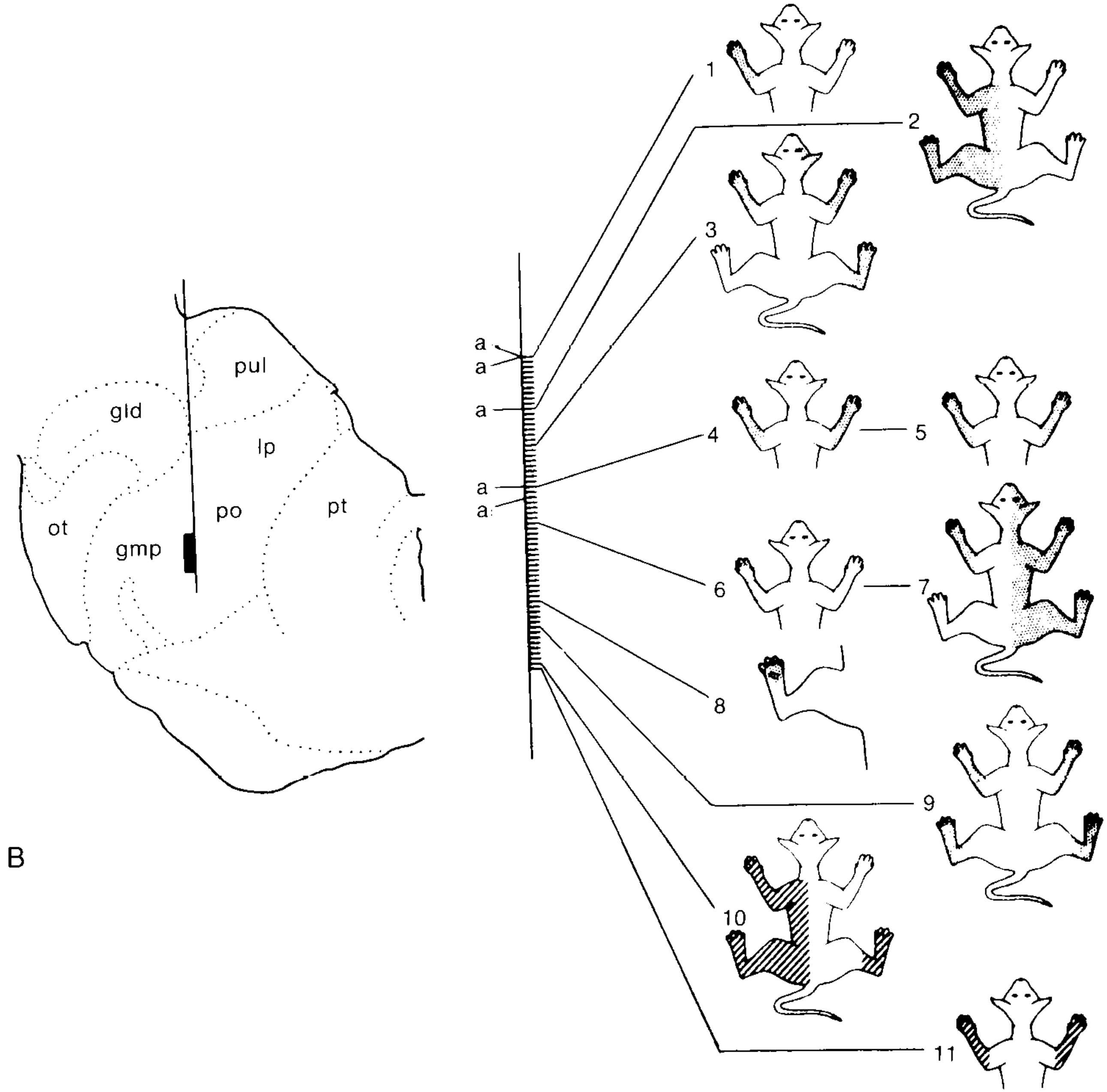


A

Relais sensitifs thalamiques

Réponses des noyaux postérieurs :

- champs récepteurs larges
- unités lentes


pul
gld
lp
po
pt
ot
gmp
a
a
a
a
a
1
2
3
4
5
6
7
8
9
10
11
B

Motricité

Expériences de stimulation corticale

- Gustave Fritsch & Eduard Hitzig (1870) (chien)
- David Ferrier (singe)
- Charles Sherrington (primates)
    – cortex moteur
- Wilder Penfield, Jasper (1950)
    - cartes cortex moteur chez l'Homme

Enregistrement neurones corticaux

- Evarts (1968) - singe

BRAIN MECHANISMS IN MOVEMENT

The highest brain functions are generally thought to be mediated in the cerebral cortex. In the control of the muscles, however, the highest function may be served by centers deeper in the brain

From Scientific American 229(1):96-103, July 1973.
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by Edward V. Evarts

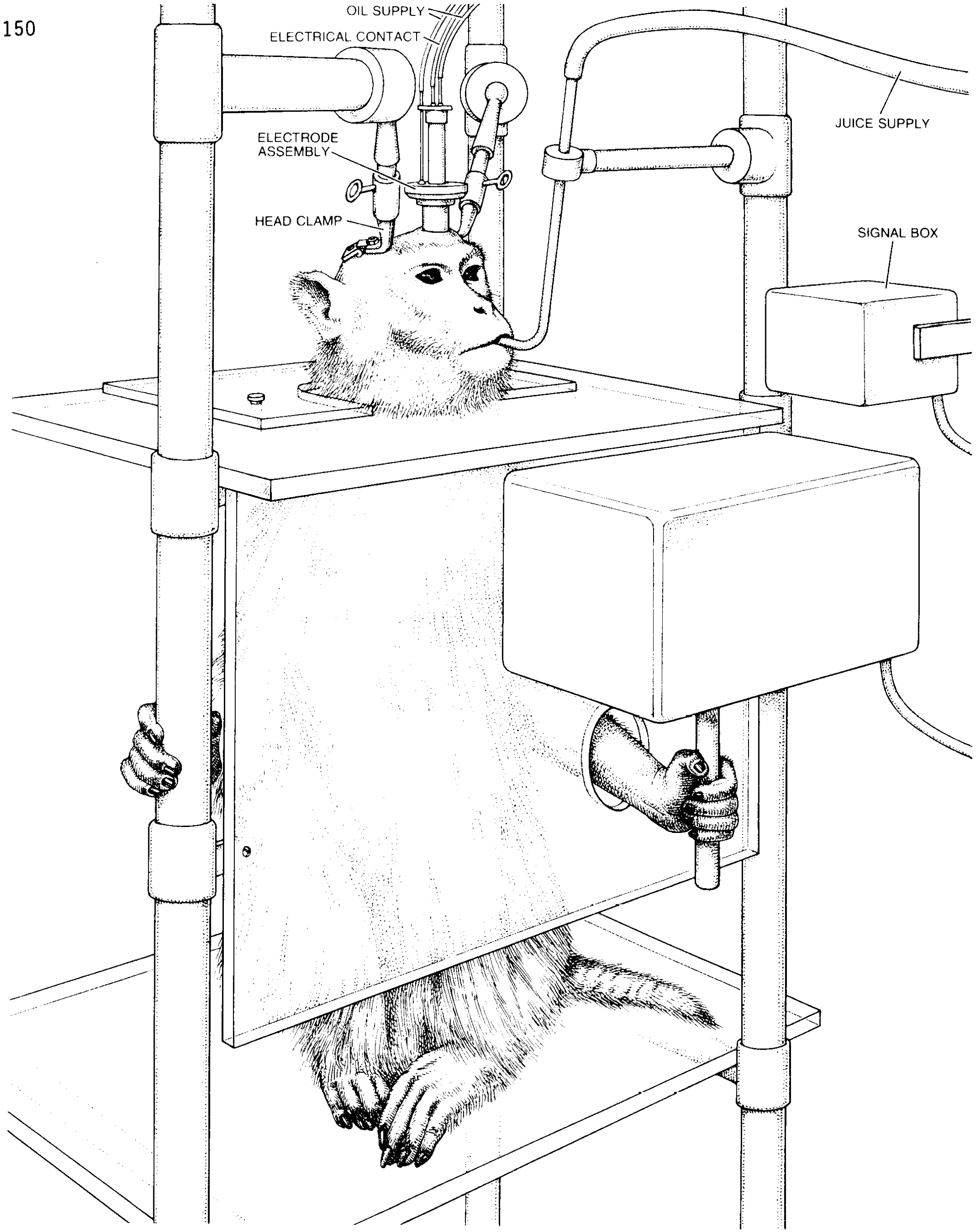
The traditional view of the brain is that the highest level in its hierarchical organization is in the cortex, or outer part, of the cerebrum. It turns out that this is not true for the brain's motor functions: the control and integration of muscular movements. Brain research has gradually revealed that the motor area of the cerebral cortex is actually at a rather low level of the motor control system, not far removed from the muscular apparatus itself. Structures lying deep below the cortex

dog's body. In 1874 Roberts Bartholow, an American physician, demonstrated that electrical stimulation of the cortical area proposed by Jackson as the site of motor control produced muscular contraction. That area is now called the motor cortex.

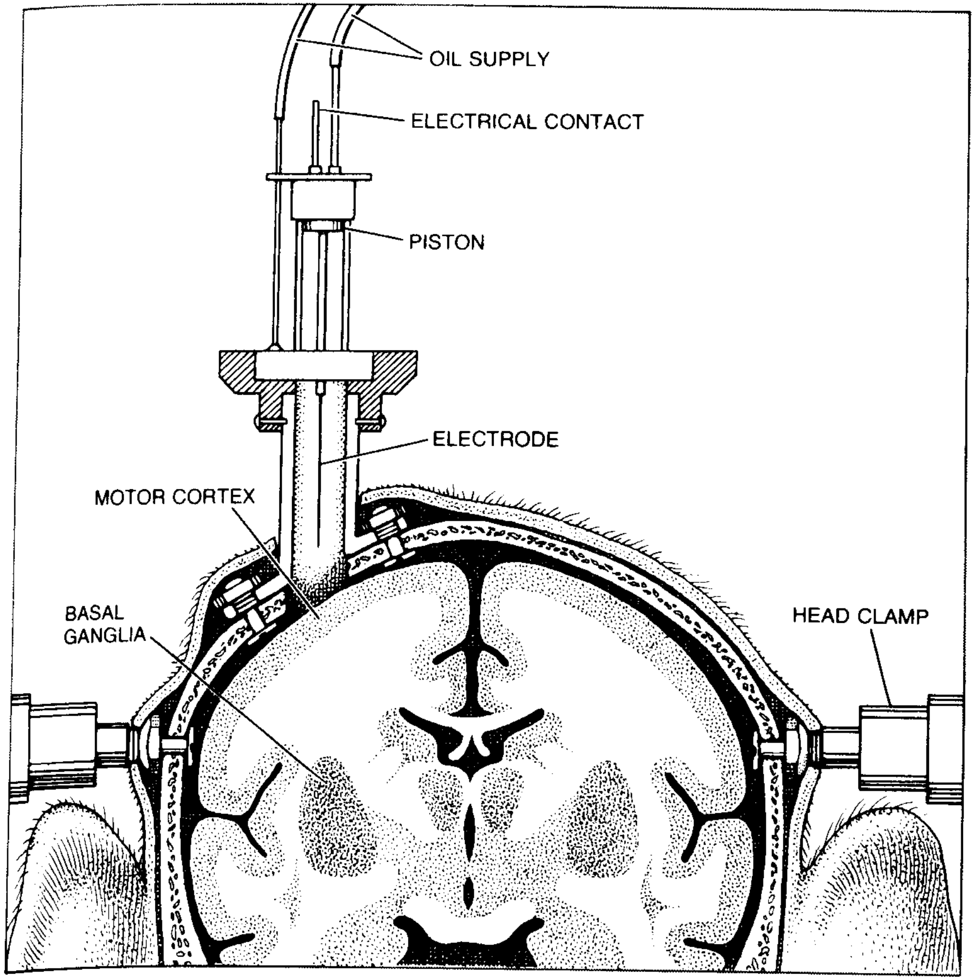
Jackson also devoted much study to focal epilepsy, a condition where convulsive movements are restricted to one part of the body, for example the thumb. He proposed that the localized movements result from excessive nerve dis-

upon circumscribed centers of the cerebral cortex."

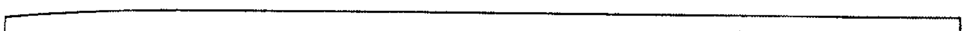
Between 1900 and 1920 Charles S. Sherrington, the foremost neurophysiologist of the time, applied the technique of electrical stimulation to study how the cerebrum controlled movement. Although he made important discoveries with this procedure, he recognized its limitations: the movements produced by the electrical stimulation of the brain are nonvolitional, resembling the movements of epilepsy more than the move-



RECORDINGS OF THE ACTIVITY

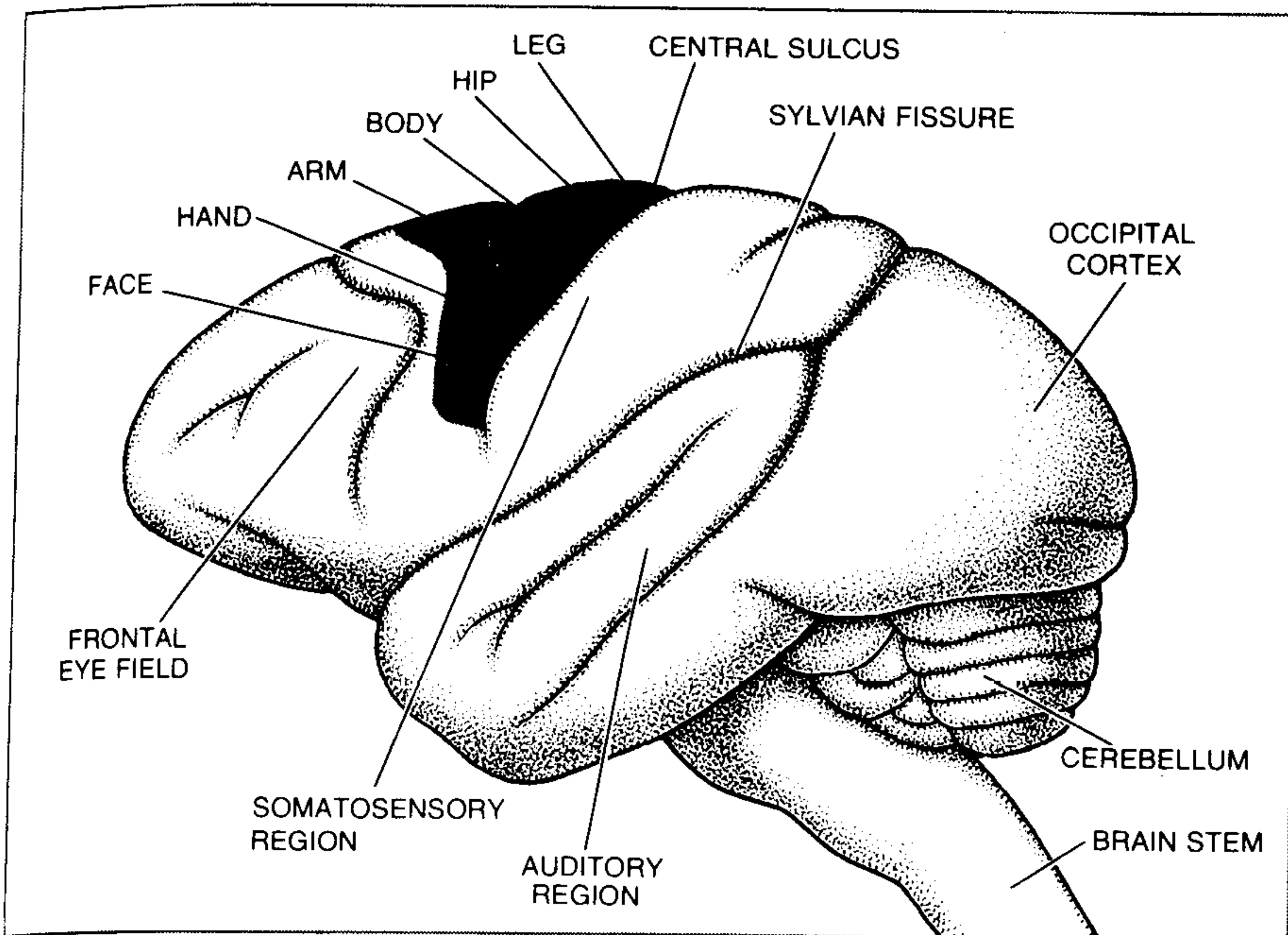


MICROELECTRODE ASSEMBLY consists of a fine platinum-iridium wire attached to a hydraulically actuated piston. A stainless-steel cylinder permanently attached to the monkey's skull provides access to the brain. The bolts on the sides of the skull are also permanently implanted. They are attached to clamps during the experiment to prevent head movement. After the electrode assembly is bolted to the cylinder the electrode is lowered by pumping oil into the inlet on the right and raised by pumping oil into the inlet on the left.

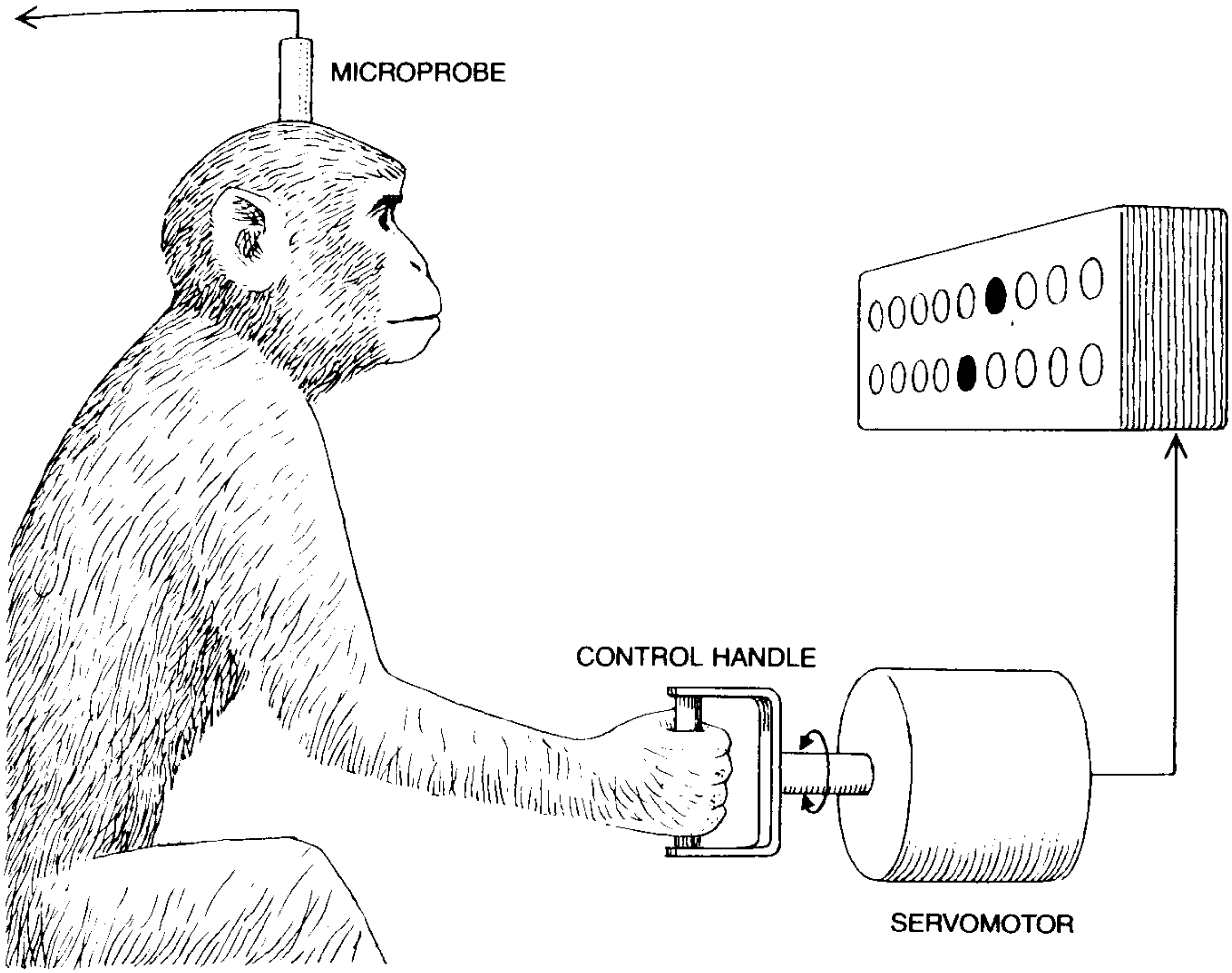


developed techniques for conditioning animals to execute certain movements that could be systematically modified and that could be readily observed and recorded in the laboratory. The greatest stumbling block was finding a way to record the electrical activity of individual nerve cells in the brain of unanesthetized animals. Cerebral nerve cells are extremely small, and in order to record their electrical discharges a microelectrode must be placed within about 50 microns of the membrane of the nerve cell. In addition the microelectrode has to remain in position even when the animal moves. Some 15 years ago Herbert H. Jasper of the Montreal Neurological Institute worked out techniques for recording the activity of individual nerve cells in animals executing learned movements. His contribution consisted in miniaturizing the system for positioning the microelectrode in the brain. The entire apparatus he developed can be attached to the animal's skull, so that head movements do not displace the recording electrode [*see top illustration at left*].

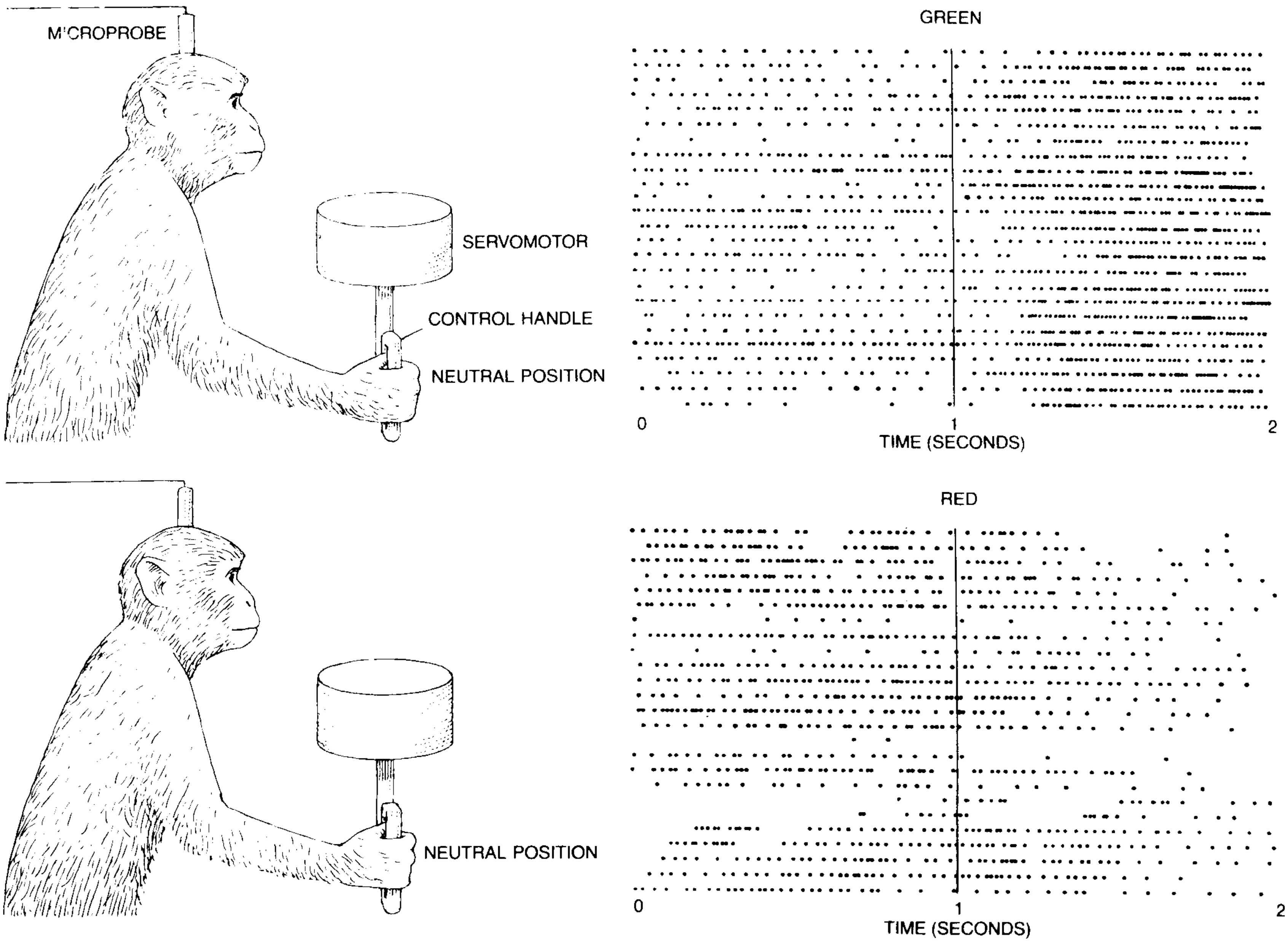
The cerebral motor cortex was long the focal point for research on how the brain controls muscular movements, but today neurophysiological studies are concerned with the cerebellum and the basal ganglia as well [*see illustrations on opposite page*]. The objective of current research is to elucidate how these three interconnected parts of the brain—the motor cortex, the cerebellum and the basal ganglia—act together to control movement.

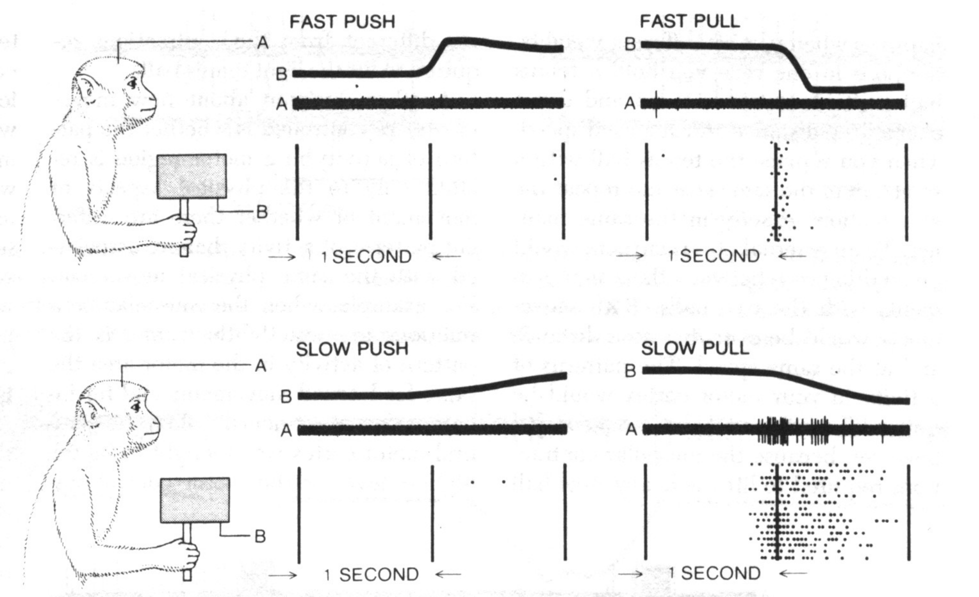


CEREBRAL CORTEX of a monkey's brain is depicted with the motor cortex, which controls muscular movement, in color. Electrical stimulation of the points indicated on the



MONKEY SUBJECTS proved amenable to training that involved precise muscular response to stimuli. In this experiment one of nine lamps in the top row of a two-row display was illuminated by the experimenter. By twisting a handle the monkey was able to "follow" the upper lamp to the left or the right and was rewarded when the two lighted lamps were aligned. A microprobe, inserted among the motor-cortex cells associated with precise manipulation, recorded the activity of the cells involved in the muscular response. Even a small voluntary movement was accompanied by a striking increase in motor-cortex activity; the proportion of brain cells that fired was far greater than the proportion of spinal-cord motor neurons involved.


MICROPROBE
SERVOMOTOR
CONTROL HANDLE
NEUTRAL POSITION
GREEN
0
1
2
TIME (SECONDS)
NEUTRAL POSITION
RED
0
1
2
TIME (SECONDS)



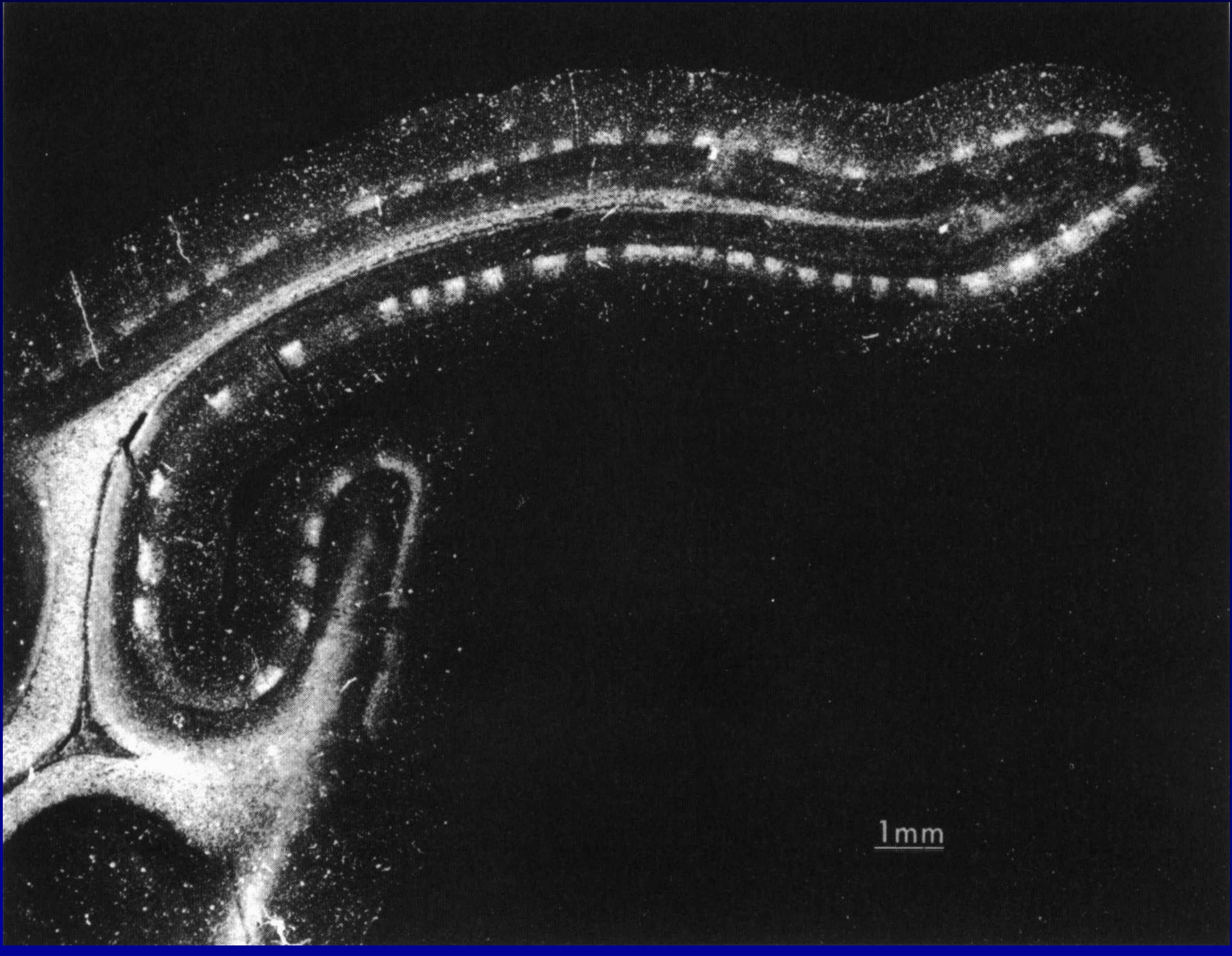
ACTIVITY OF A SINGLE NERVE CELL in the basal ganglia during pushing and pulling

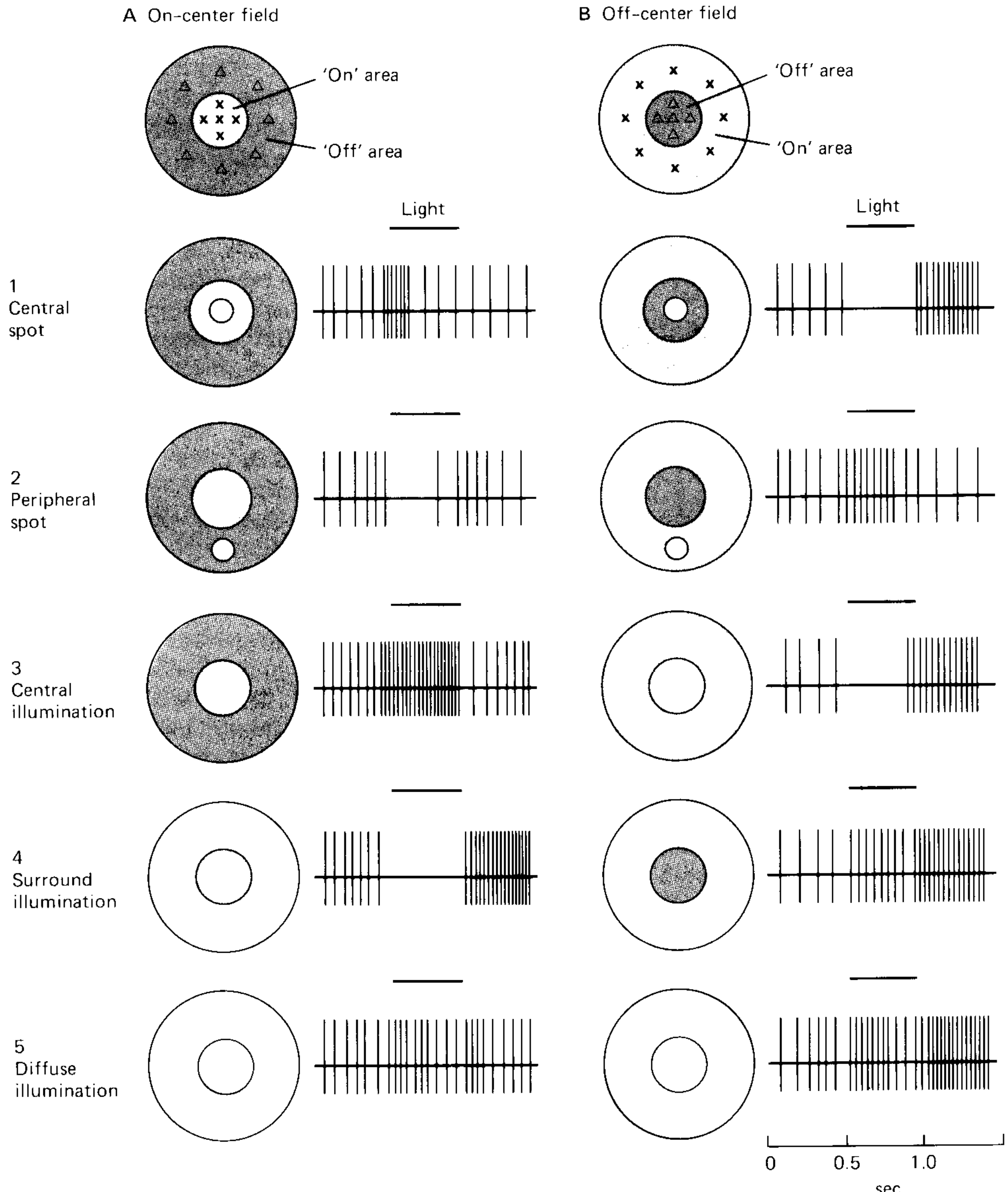
Système visuel

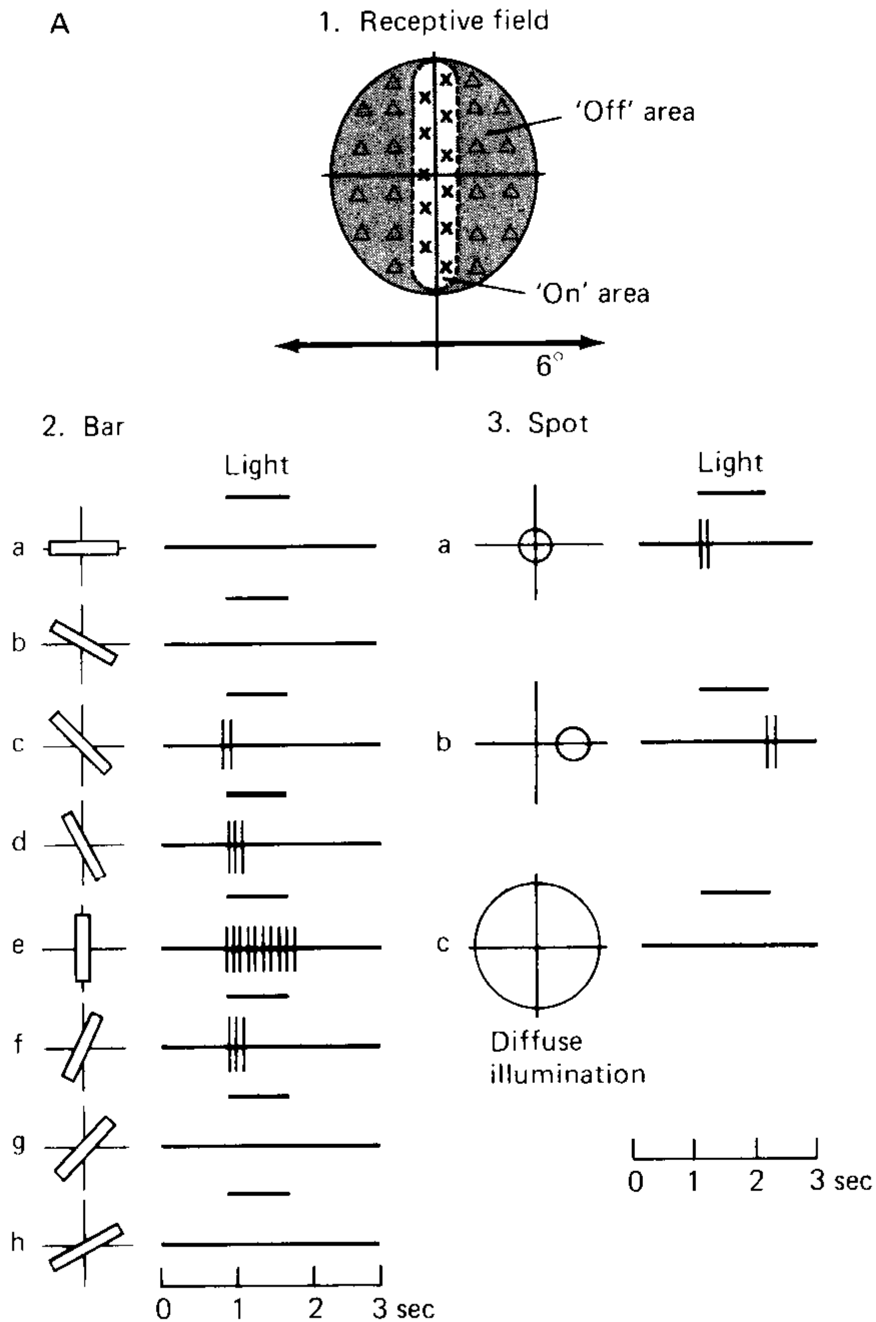
• Hubel & Wiesel

• cortex visuel primaire : rétinotopie et colonnes de dominance oculaire

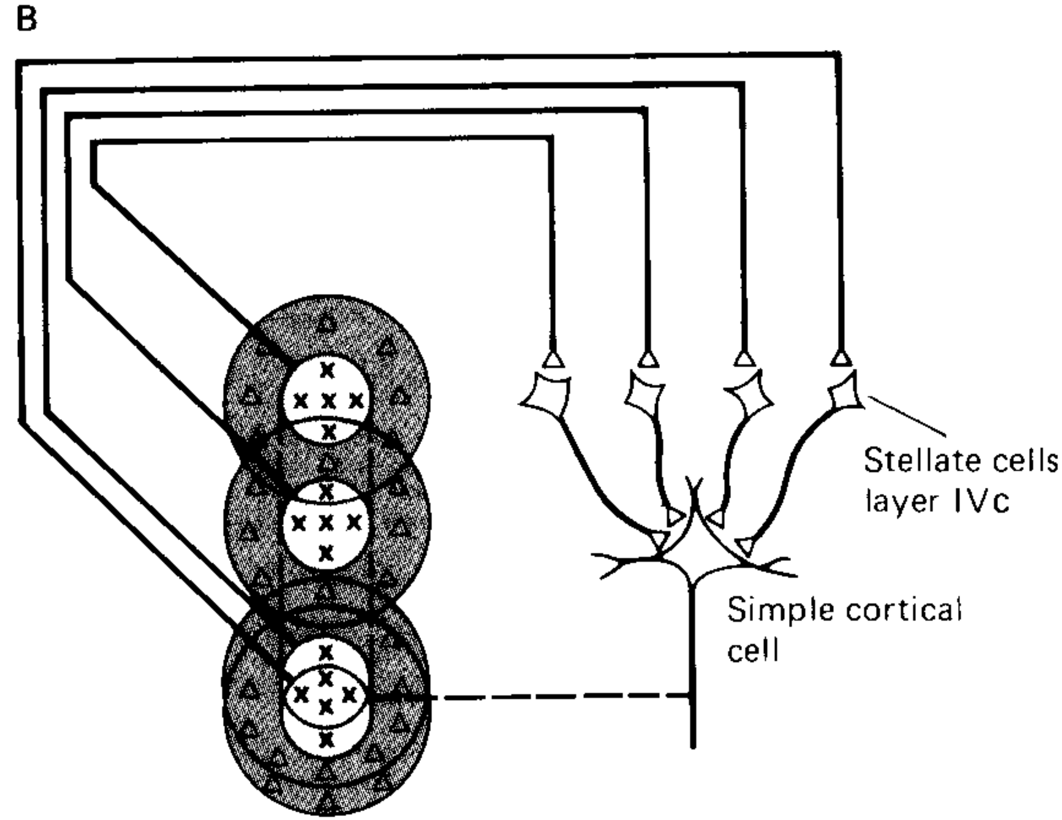
• aire V1 : neurones à champs récepteurs ON ou OFF, neurones simples, complexes…


1mm

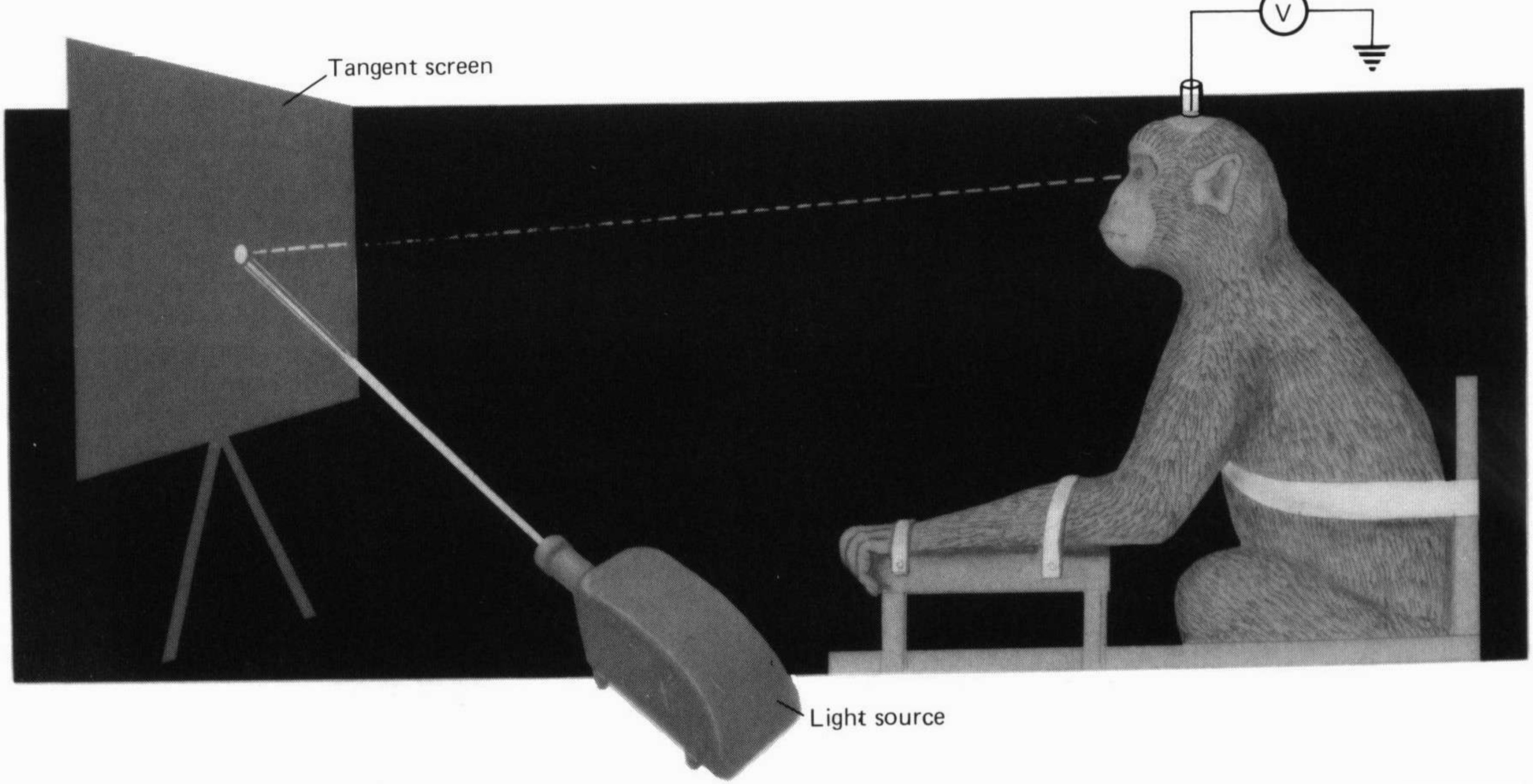

A On-center field
'On' area
'Off' area
B Off-center field
'Off' area
'On' area
Light
Light
1
Central
spot
2
Peripheral
spot
3
Central
illumination
4
Surround
illumination
5
Diffuse
illumination
0
0.5
1.0
sec



A
1. Receptive field
'Off' area
'On' area
6°
2. Bar
Light
a
b
c
d
e
f
g
h
0
1
2
3 sec
3. Spot
Light
a
b
c
Diffuse illumination
0
1
2
3 sec


B
Stellate cells
layer IVc
Simple cortical
cell

Processing of Form and Movement in the Visual System



The Rat Brain

in Stereotaxic Coordinates

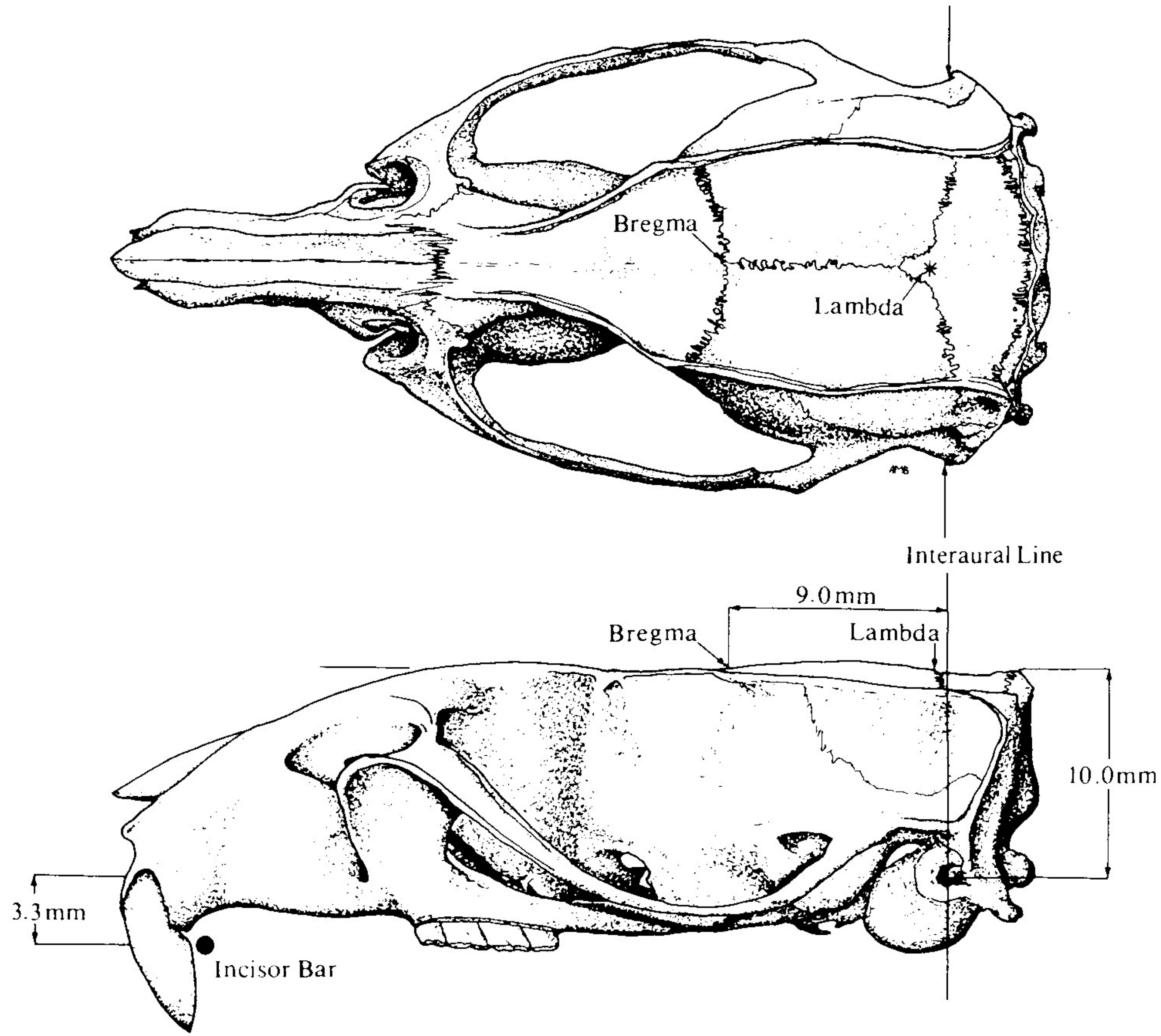
Second Edition

George Paxinos

School of Psychology
University of New South Wales

Charles Watson

Department of Health
Perth, Western Australia



Bregma
Lambda
Interaural Line
9.0mm
Bregma
Lambda
10.0mm
3.3mm
Incisor Bar

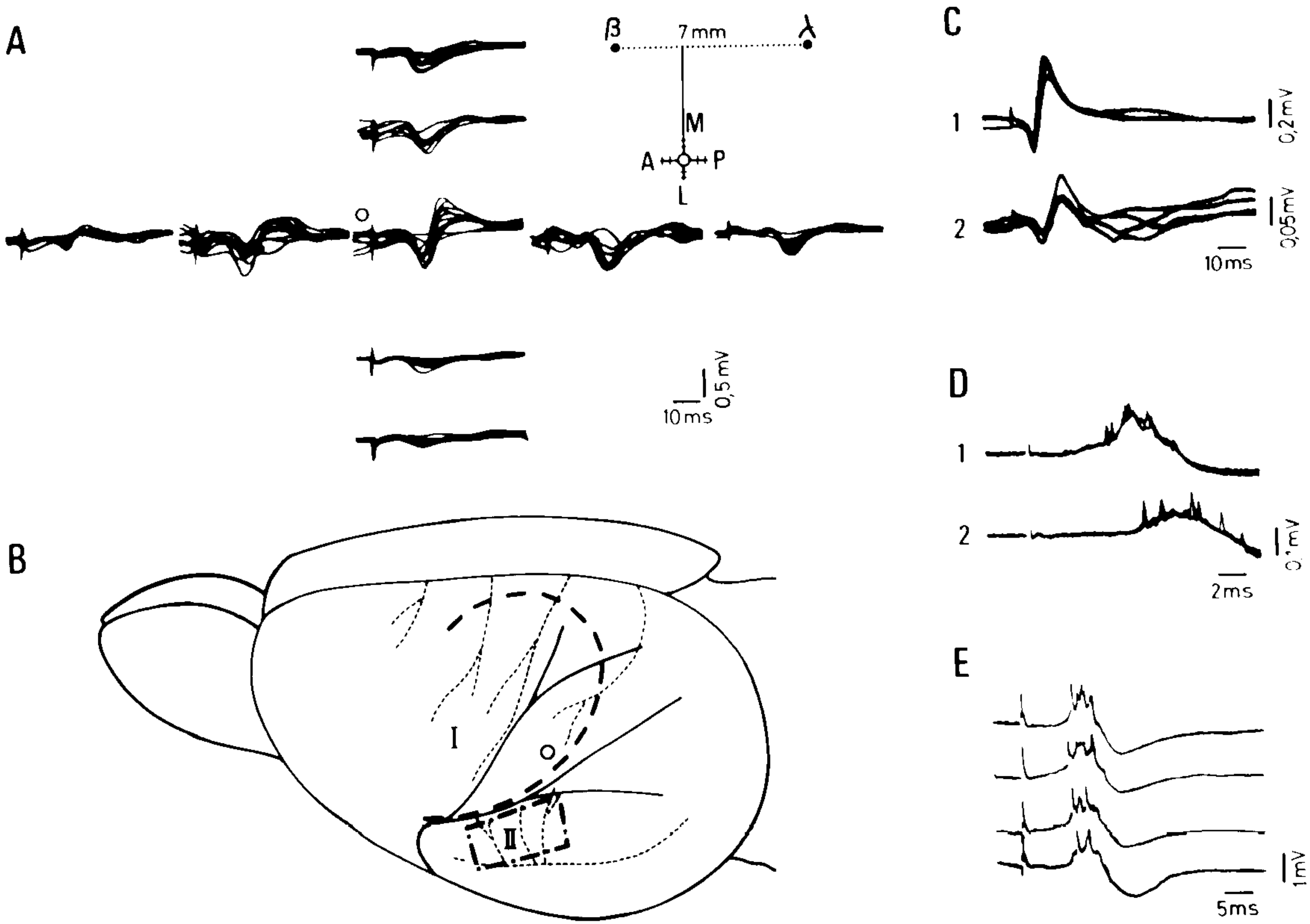
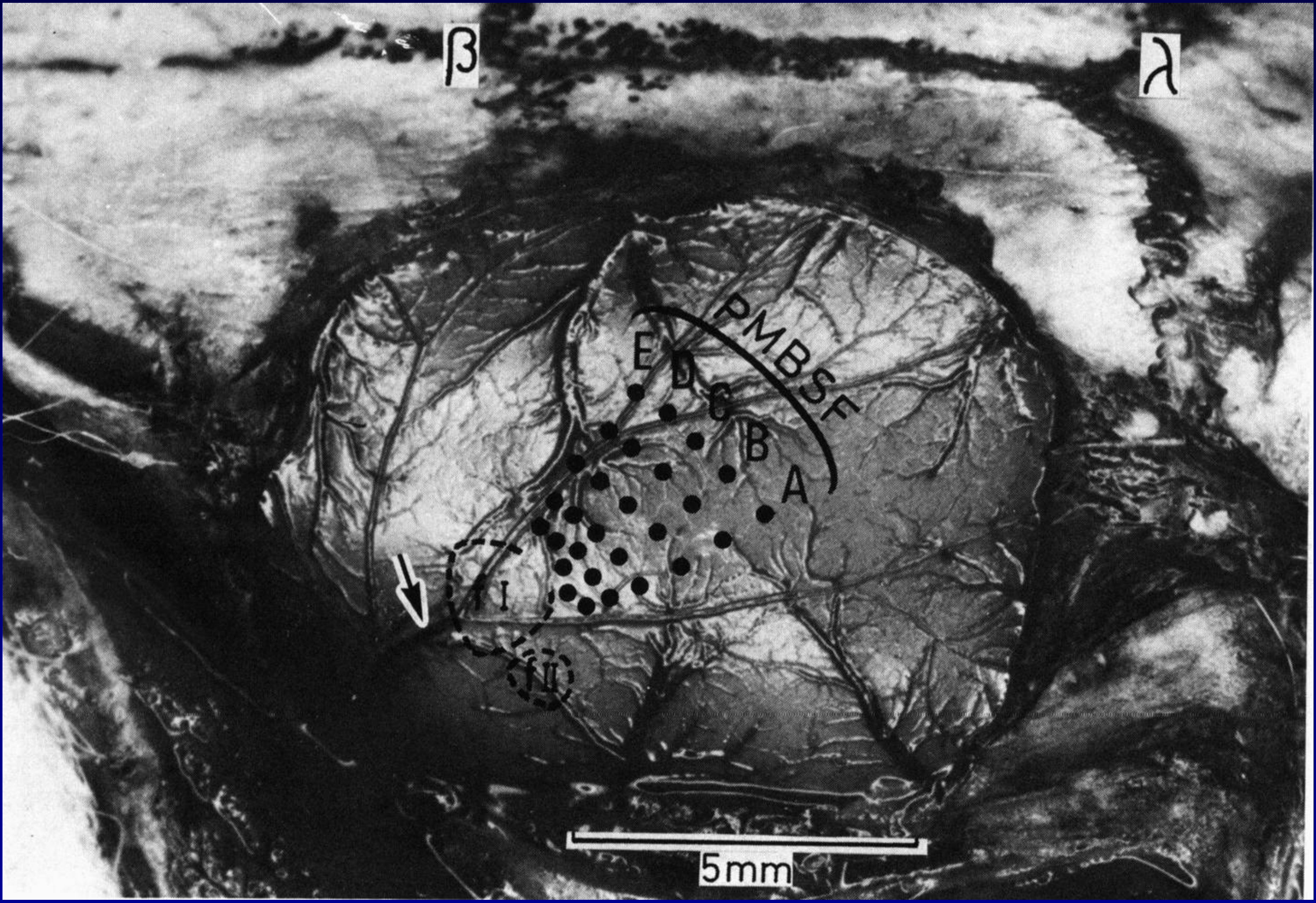
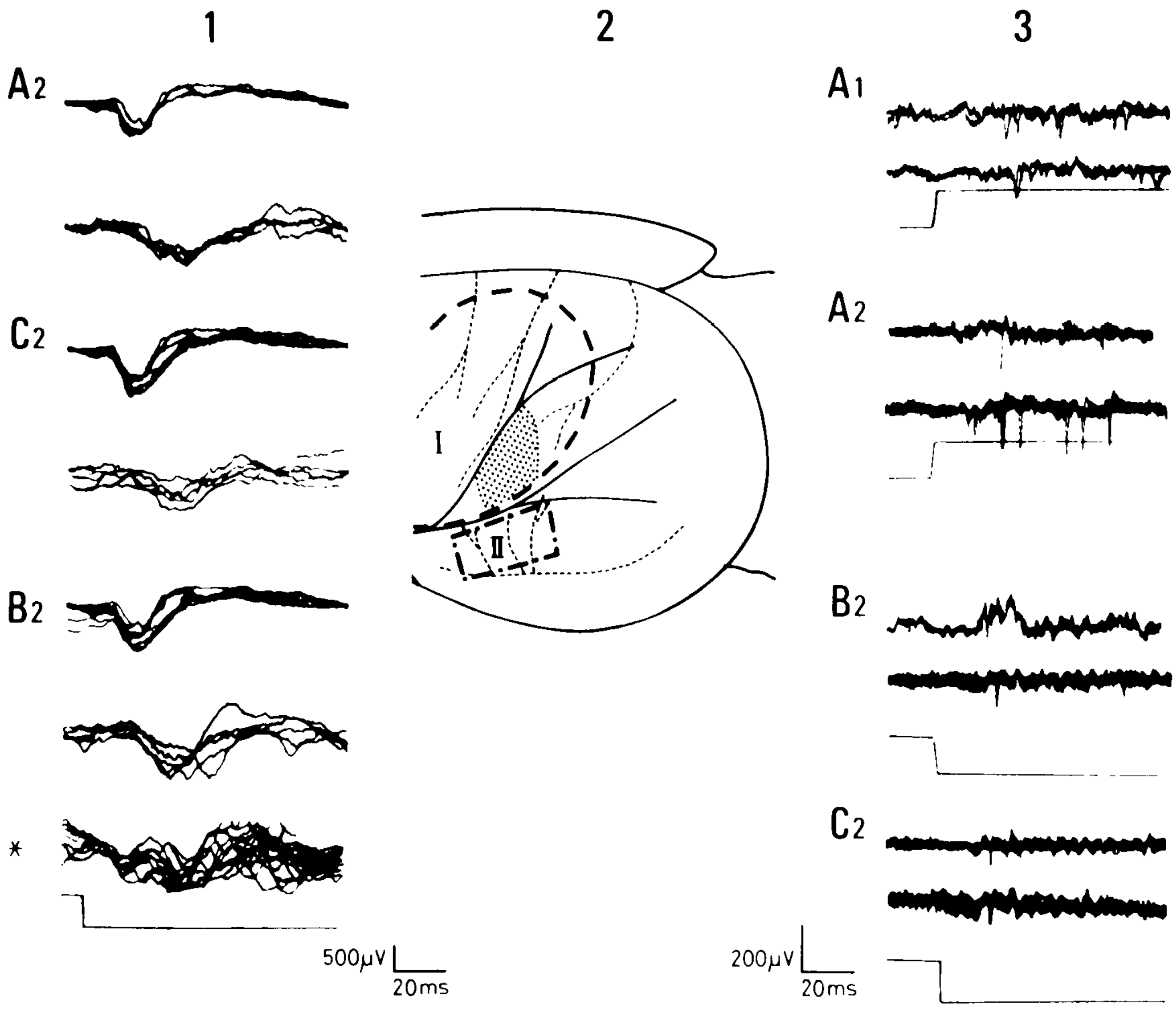
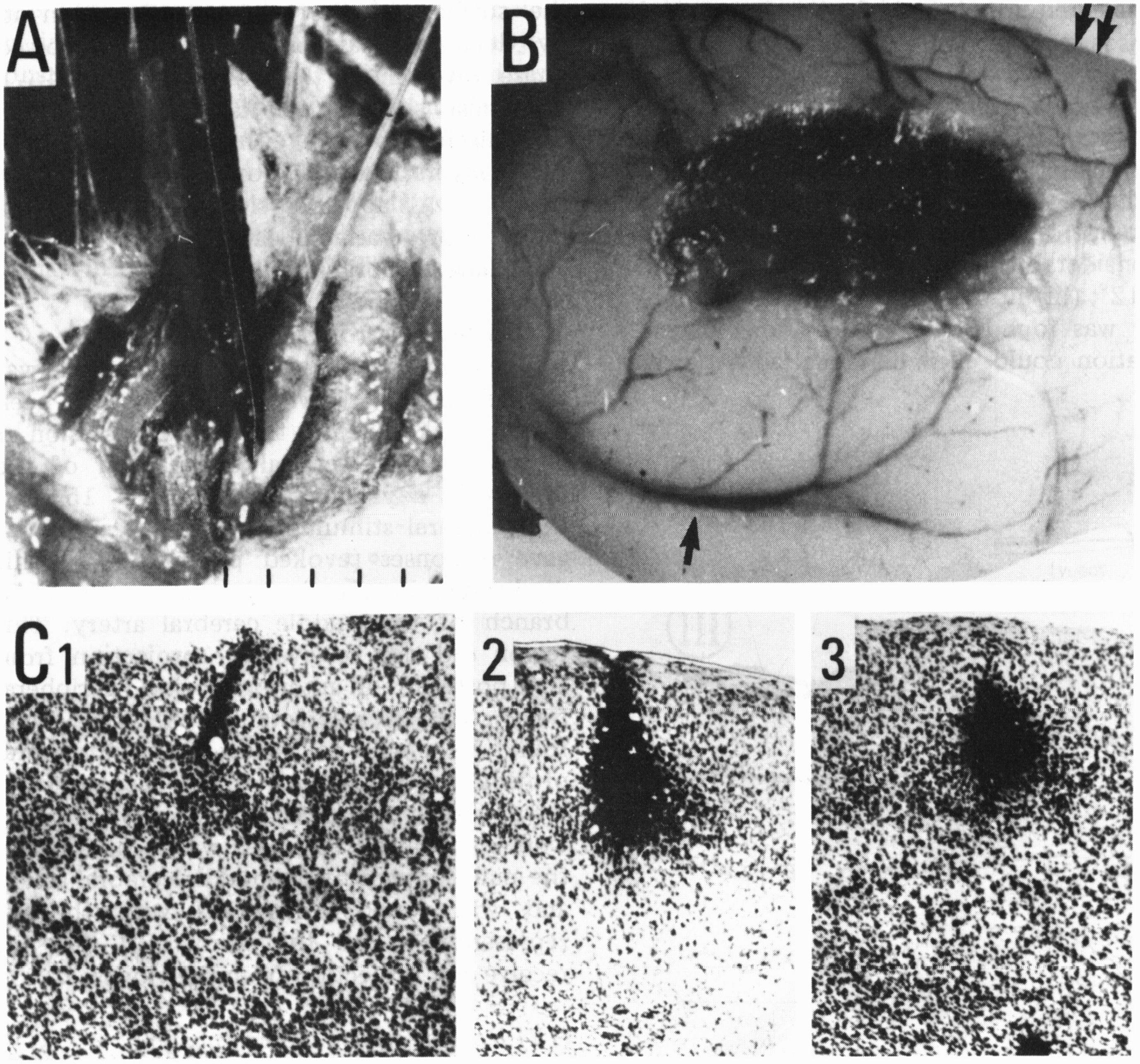


Fig. 2. Potentials elicited on SI by electrical stimulation of single follicle nerves (rats). A: display of potentials on left SI from a nerve of the ipsilateral A2 vibrissal follicle. Mapping interpoint interval is 200 μm. Focal potential


β
λ
PMBSF
E
D
C
B
A
f I
f II
5mm


1
2
3
A2
C2
B2
*
I
II
A1
A2
B2
C2
500μV
20ms
200μV
20ms


A
B
C1
2
3

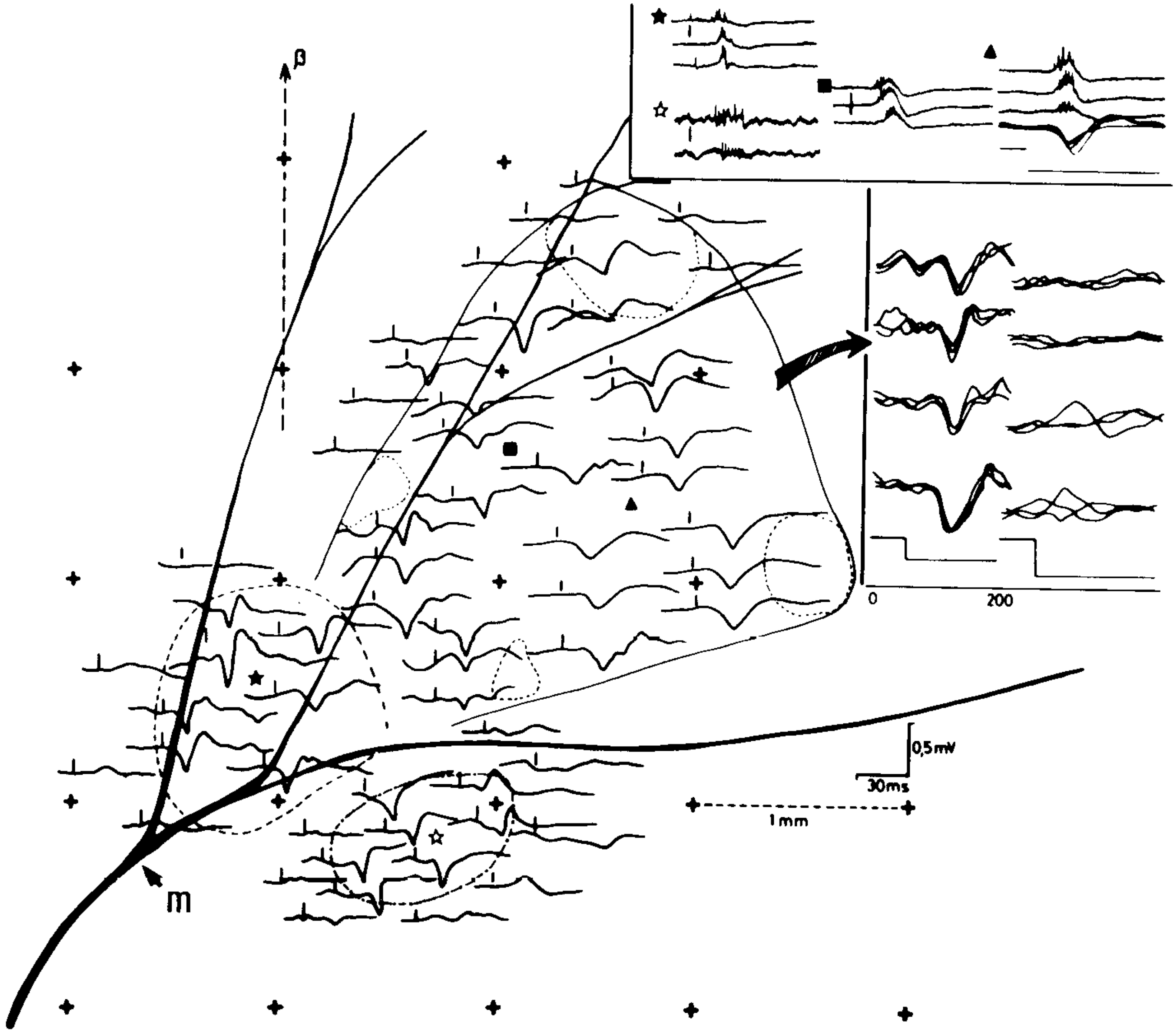


Fig. 2. Extension of the projection for fur stimulation in an adult rat dewhiskered since

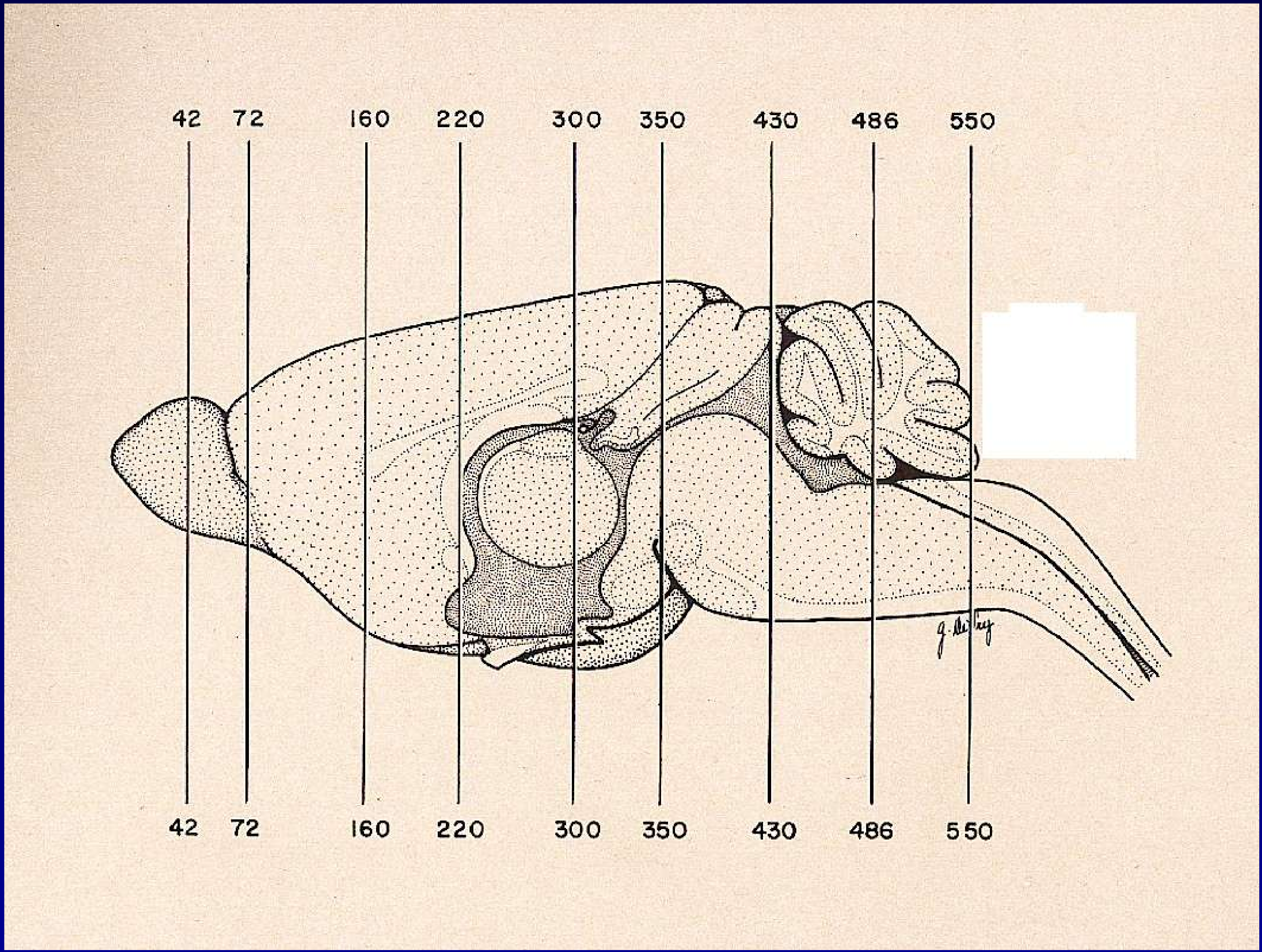
Atlas of the Mouse Brain and Spinal Cord

Richard L. Sidman, M.D.
Bullard Professor of Neuropathology, Harvard Medical School

Jay B. Angevine, Jr., Ph.D.
Professor of Anatomy, College of Medicine, University of Arizona

Elizabeth Taber Pierce, Ph.D.
Associate in Anatomy, Harvard Medical School

A Commonwealth Fund Book
Harvard University Press, Cambridge, Massachusetts 1971


42
72
160
220
300
350
430
486
550
42
72
160
220
300
350
430
486
550

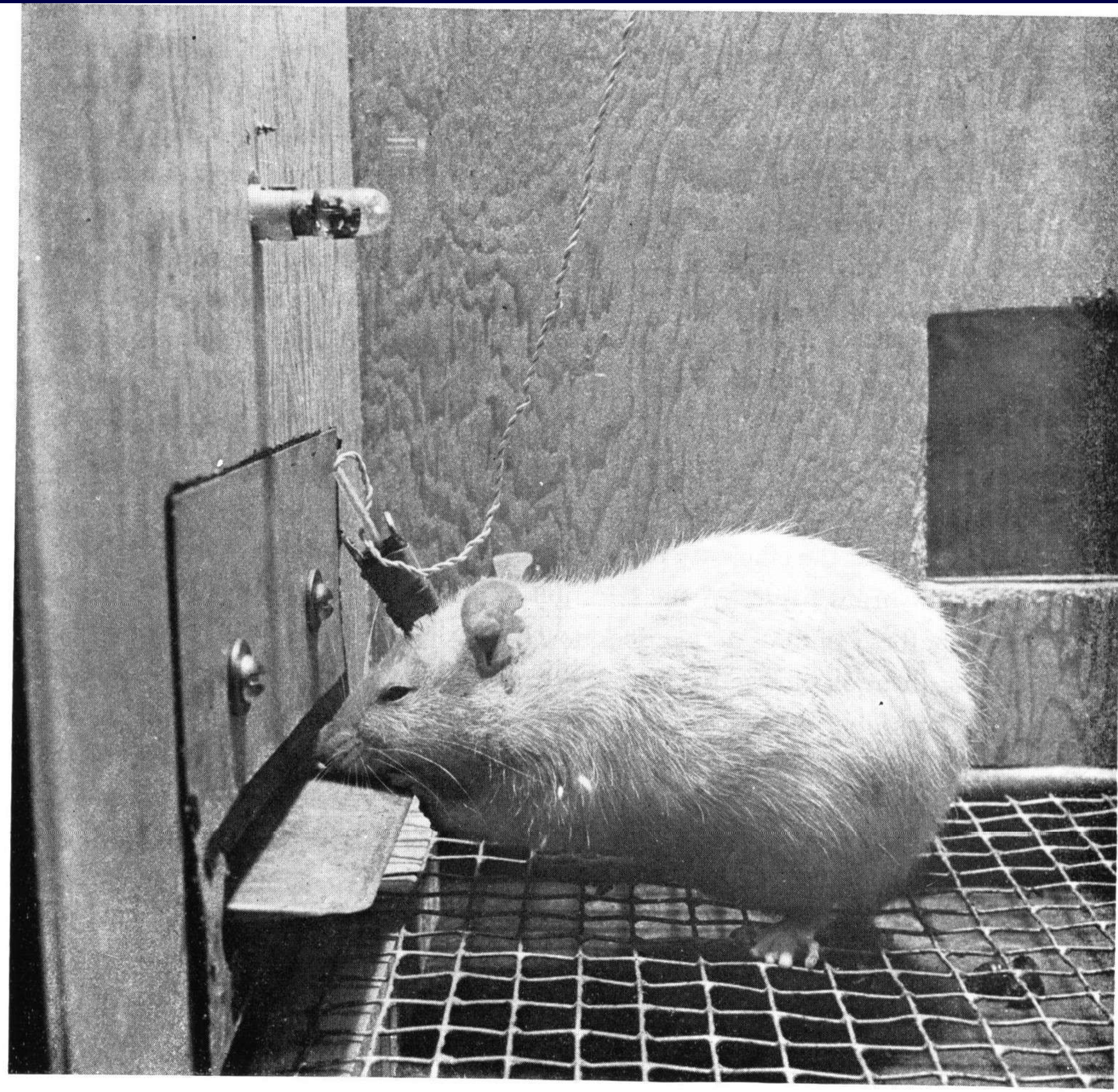


Fig. 137. A white rat in a Skinner box. In this case chronically implanted electrodes make it possible to stimulate different parts of the brain. The lever

Conclusions