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NEURONAL ADAPTIVE MECHANISMS UNDERLYING INTELLIGENT INFORMATION PROCESSING

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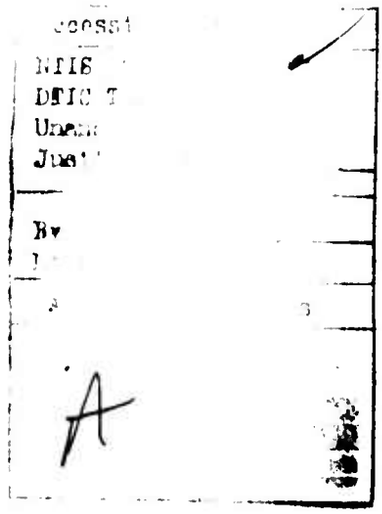

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* The experiments reported herein were conducted according to the principles described in Guide for the Care and Use of Laboratory Animals DHEW Publication #(NIH) 78-23.

SUMMARY

By means of this grant, advances were made in:

1. Identifying key features controlling adaptation in neural networks.
2. Developing and calibrating a device for pressure injection of minute volumes through fine micropipettes.
3. Examining, intracellularly, the response of single cortical neurons to:
   a. a behavioral unconditioned stimulus used to produce conditioned behavior;
   b. an unconditioned stimulus produced by direct electrical activation, antidromically, of single, pyramidal tract neurons;
   c. direct application of pharmacologic agents thought to cause neural adaptation.
4. Simulating adaptive features of single neurons.
5. Altering rates of acquisition of conditioned behavior by direct neuromodulatory procedures.

The results have led to an improved understanding of neuronal adaptive mechanisms underlying intelligent information processing by the brain and afford the design of improved components for use in artificial intelligence.

STATEMENT OF WORK

The human brain is the most powerful adaptive network known to man. It is responsible for human intelligence with operations involving automated image recognition, speech, decision making and complex motor functions. The same functions are the goal of artificial intelligence operations, robotics and the like. Attempts to design machines to perform these functions successfully would benefit from an understanding of how the brain has succeeded in doing so.

Both brain and machine depend on component operations. There is reason to believe that systems supporting complex goal-seeking adaptive behavior are best constructed out of goal-seeking adaptive components. Limited understanding of how such components work has prevented their incorporation into present artificial intelligence systems.

In the brain the basic component is the neuron. Recent studies indicate that single cortical neurons adapt in such a way as to support adaptive mammalian behavior. Post-synaptically, adaptation is reflected at the cellular level by a change in neural excitability to injected current. We have focussed our studies on analysis of this type of adaptation.

Twenty-four publications have resulted from the research in this period; see list of publications - Section D. The ultimate goal of the research is to provide a foundation for the design of improved adaptive network architectures.

COMPREHENSIVE PROGRESS REPORT - STATUS OF RESEARCH

The general objective was to improve our ability to design adaptive network architectures by investigating neuronal adaptive mechanisms underlying intelligent information processing in the brain. It would be useful to determine if cellular mechanisms controlling adaptation operate in a manner analogous to goal-seeking. The latter might be a function of excitatory or inhibitory ionic conductances, cyclic nucleotide gradients, or other measurable variables that could persistently influence the level of neural excitability. The main approach was to study control of changes in cellular excitability directly in single cortical neurons.

A. Specific Objective 1 was to compare current knowledge of elemental component operations of adaptive networks in the brain with those of artificial, heterostatic adaptive systems. Ten conferences and one 2-week workshop were held (Table 1). The discussions succeeded in identifying key cybernetic features controlling adaptation of artificial networks as well as several parallel neurophysiological mechanisms which could potentially serve as substrates for controlling neural adaptation. Current knowledge of heterostatic control of goal-seeking adaptive systems was related to possible neurophysiological mechanisms that might serve to control plasticity at the cellular level and the following conclusions were drawn:

1. An adaptive system can be described, cybernetically, as a system that modifies its internal structure as a function of experience, thereby altering the system operation. Ordinarily, the system operation will become increasingly optimized, by means of feedback, in the approach to some operational goal. In this context goal-seeking will be the process by which the component or adaptive element moves toward or maintains a particular system state.

2. A key feature of any adaptive system will be the features controlling the adaptation. The control sub-system may or may not require associated memory. If so, the memory may evolve in a trivial or non-trivial fashion, with or without variation in the original set point.

3. Control of goal-seeking may be expected to be accomplished by means of feedback. The latter will ordinarily involve some closed-loop operations. Interestingly, a great many psychophysiological formulations of adaptive neural systems have neglected to specify closed-loop operations by which such feedback could be accomplished as opposed to open-loop operations which do not lend themselves to modification of the involved element as a consequence of the element's past adaptation (c.f. Kandel and Spencer, 1968).

4. Physiologically, many adaptive cellular systems lend themselves to closed-loop goal-seeking processes. These range from biochemical feedback loops (within the metabolic context of the cell itself) to recurrent collateral systems with relatively direct feedback as well as indirect feedback through more extensive polysynaptic networks (cf. Rasmussen and Goodman, 1977, Phillips, 1974).

5. At the level of cellular components in the brain, there exist several candidate mechanisms for the control of neural adaptation.

a. The "Yin-Yang" hypothesis has been advanced in which so-called excitatory and inhibitory neurotransmitters could control closed-loop goal-seeking adaptations depending upon neuronal conductance changes by means of intracellular second messengers such as cyclic AMP and cyclic GMP. The cyclic nucleotides are thought to interact reciprocally to facilitate either excitatory or inhibitory effects (Bloom, 1975, 1976; Goldberg et al. 1973).

b. The principle of voltage-dependent control of neuronal spike activity is well establisned. The possibility arises of voltage dependent induction or potentiation of cyclic nucleotide release as well as the likelihood of coupled sodium or potassium-calcium channels with voltage-dependent features (Loewenstein, 1975; Lux and Eckert, 1974; Heyer and Lux, 1976a,b).

c. Entrainment, i.e. the production of multiple spike discharges encroaching upon relative refractory periods, might furnish a chemical signal for cellular mechanisms controlling neural adaption, particularly after associative stimulus pairings as in conditioning. In cortical neurons, entrainment is probabilistically an uncommon event in contrast with PSP or spike production, per se, resulting from natural auditory stimuli which serve as CS's in Pavlovian blink conditioning (Woody et al. 1970; Engle and Woody, 1972). Other recent evidence (Woody et al. 1976d) indicates that entrainment might interact with acetylcholine or cyclic GMP to control aspects of persistent adaptation in mammalian cortical neurons.

6. The practical significance of using a closed-loop cybernetic approach to understand cellular adaptation, even at the biochemical level, is just beginning to be re-evaluated and appreciated. For example, the following is excerpted from a recent review by Rasmusser [illegible]man (1977).

B. Open-Loop vs. Closed-Loop Control Systems

1. General features

Nearly all models of peptide and amino hormone action, including the second-messenger model, have been ones in which a stimulus (the hormone) acts on a particular cell or subcellular system to produce a physiological response. In cybernetic terms, this is defined as an open-loop system (Fig. 2).

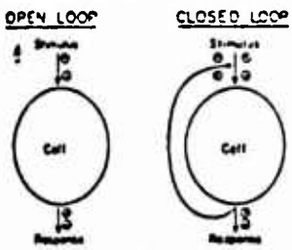


FIG. 2. Schematic representations of the contrast between open-loop and closed-loop systems in the control of cellular response.

However, in biological systems at all levels of organization, responses are dependent not only on present and past stimuli but on the response itself, according to the present organization of the unit and its particular environment. This means that cellular responses to hormonal stimuli operate not as open- but as closed-loop systems. The distinction is critically important: in an open-loop system the response depends on the stimulus, but the converse is not true. In contrast, in a closed-loop system the response influences the stimulus—i.e., there is a feedback relationship between stimulus and response such that the response itself modifies the effect and magnitude of the original stimulus. Endocrine physiologists have realized for years that at the supracellular level endocrine systems operate as complex, closed-loop systems (327), yet most endocrine biochemists continue to analyze hormone action at the cellular level in the context of open-loop models (126, 190, 415).

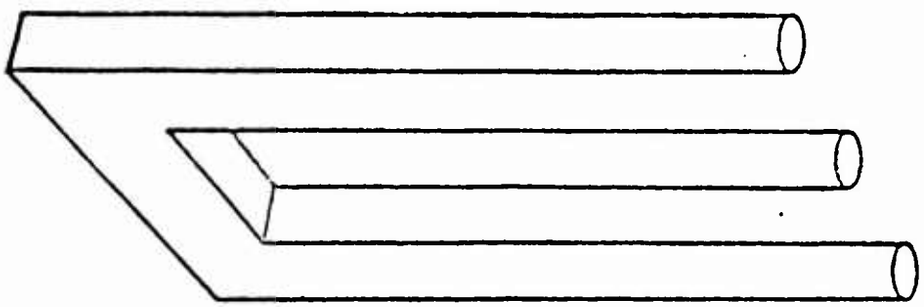
Considering these cellular control systems as closed-loop systems as schematized in Figure 2, rather than an open-loop yin-yang system as proposed by Goldberg et al. (165), adds an important dimension to both one's understanding of the system and to the types of critical experiments one can design to evaluate the hypothesis.

The importance of making this distinction in analyzing hormone action lies in the kinds of models of hormone action one builds from experimental data and from these the type of further experiments one designs to test these models. Of even greater import, if closed-loop systems are the biological rule, then an understanding of feedback theory provides a means of obtaining a correct intuitive grasp of the nature of the control system in many situations in which an open-loop analysis of the same experimental data would lead to a confusing and contradictory conclusion.

(From Physiological Reviews)

Systems of this type are of course restricted in the type of operations they can perform and the geometric patterns that can be recognized. For example, such systems cannot compute connectedness of geoemetric figures, whereas they can compute convexity and related processing operations of the type called local or conjunctively local by Minsky and Papert. Humans may not be able to compute some forms of connectedness either:

e.g.:



9. The possibility exists that a slight modification of Uttley's algorithm can result in the introduction of a self-classifying input. By self-classifying input is meant an input of particular functional significance which is identifiable, within the adaptive element, by means of its stochastic pattern of appearance alone. Moreover, this stochastic pattern need not unduly disrupt the overall function of the adaptive element's operation.

B. Specific Objective 2 was to develop microtechniques for rapid chemical stimulation of cortical neurons.

1. A device was constructed by which micro amounts of neurotransmitters, cyclic nucleotides or other pharmacologically active agents could be delivered through fine pipettes placed intracellularly or extracellularly into the milieu immediately surrounding an intracellularly recorded cortical unit (Sakai et al. 1978a). Passage of this material through pipettes with lumens of $\leq 1\mu$ was achieved by combining siliconization of the pipette barrel with applied pulse pressures of 60-90 Psi. The use of pressure avoids the undesirable side effect of current injection which is associated with previous iontophoretic procedures.

2. The quantities of material delivered by such means through pipettes of tip size 0.5 - 1.5u were determined in vitro and found to be more precise, quantitative and reproducible than those delivered by iontophoresis (Fig. 1 and Sakai et al. 1978c). The high variability in amounts released by iontophoresis, the problem surrounding electro osmotic side effects of current passage on delivery, and the need for lengthy "warm-up" periods during which active agents are released through the pipettes are well-known and documented in the past literature (Hoffer et al. 1971; Zieglgansberger et al. 1974). The pressure microinjection technique appears to circumvent these problems. Fig. 1 shows reproducible delivery of volumes 1,000 - 10,000 times smaller than those previously obtained by any pressure microinjection technique. Controlled release of 100 femtoliter volumes are obtained (cf. Sakai, et al., Neuropharmacol., 1979). A number of other laboratories are adopting this technique for testing local biological effects of pharmacologic agents.

7. The informon model of an adaptive neural element (Uttley, 1976a) incorporates classifying inputs, closed-loop feedback concerning the operational state of the element, and an appreciation of goal-seeking in the algorithm regulating useful adaptation. Several constraints are particularized that are critical if the informon is to successfully discriminate one input from another. These are a) the algorithm by which the weightings of synaptic inputs are altered, b) the need to achieve system normalization through negative (not positive) feedback of information regarding the current system state, and c) the need for a classifying input to distinguish or identify which input signal is the particular signal to be discriminated. Tests of this model have found that each of these constraints is required for the element to adapt usefully. Synaptic weighting is altered according to the Shannon mutual information function between certain synaptic inputs in combination with closed-loop negative feedback reflecting the element's internal state.

In summary, it would appear that there are empirical as well as theoretical reasons why "smart" adaptive elements need to incorporate goal-seeking as well as closed-loop feedback into their design.

8. In some adaptive networks, input analysis, i.e. the processing of sensory-labelled information (cf. Mountcastle, 1974), is explicable in terms of the group invariance theorem of Minsky and Papert. This theorem permits analysis of operations, such as the geometry of certain sensory image processing, by algebraic means instead of statistics and thereby reverses a trend in this field. The group invariance theorem examines the relationship between all possible receptor activations (all sets of sensory labels) and their representation across the theoretical space of an adaptive network, given certain architectural constraints. The result is a description of an orderly relationship in which no matter how complexly the network is organized, the space required for a particular sensory labelling can be specified. In summary form, the group invariance theorem states that if:

I) G is a finite group of transformations of a finite space R;

II) $\underline{\Phi}$ is a set of predicates on R closed under G;

III) Ψ is in L ($\underline{\Phi}$) and invariant under G.

Then there exists a linear representation of

$$\Psi = \left[\sum_{\varphi \in \underline{\Phi}} \beta_\varphi \varphi > 0\right]$$

for which the coefficients β_φ depend only on the G-equivalence class of φ, that is if $\varphi \underset{G}{=} \varphi'$ then $\beta_\varphi = \beta_{\varphi'}$.

L $\underline{\Phi}$ is the set of all predicates for which Ψ is a linear threshold function with respect to $\underline{\Phi}$, and a predicate is a function that has two possible values, i.e. a binary function.

Ψ is a linear threshold function with respect to $\underline{\Phi}(\Psi \text{ is in } L(\underline{\Phi}))$, if there exists a number θ, and a set of numbers, α_φ one for each φ in $\underline{\Phi}$, such that:

Equation 7.6

$$\Psi(x) = \left[\sum_{\varphi \in \underline{\Phi}} \alpha_\varphi \varphi(x) > \theta\right]$$

FIGURE 1.

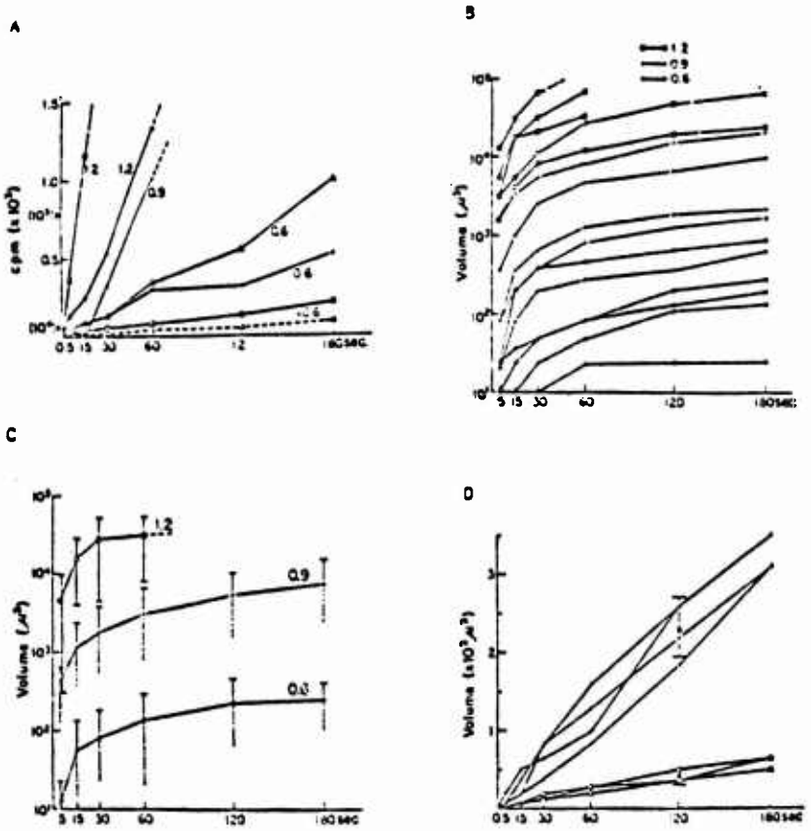


Figure 1 Measurement of volumes delivered through micropipettes of tip size 0.6, 0.9 and 1.2μ by pressure application.

A. Direct measurement of ^{3}H - Acetic acid (CPM) extrapolated to volume delivered in μ^3 (10^4 - 10^5). Each line represents a different micropipette with tip size as shown.
B. Quantitative delivery of volumes ranging between 10^1 - $10^5\mu^3$ from a group of 15 pipettes. These volumes were determined by measuring the size of the extruded droplet in oil under a microscope. This permitted accurate measurement of the smallest volumes delivered, which were below the noise-sensitivity level of scintillation counting of ^{3}H Acetic acid. Where the data overlapped, there was general agreement between the two techniques of measurement.

C. Shows the data from part B, averaged for electrodes of three different tip sizes. The volumes delivered depend on tip size and the duration of pressure application. Note the log - log plot.

D. Volumes obtained by repeated pressure application through two different electrodes, one $\geq 9\mu$, the other $\leq 9\mu$. Mean and standard deviations are shown at 120 sec. The reproducibility is good, even for small volumes of $<< 10^3\mu^3$, relative to that afforded by other techniques.

3. Morphological identification of electrophysiologically studied cortical neurons was found possible by pressure microinjection of a marking agent, horseradish peroxidase (HRP), through the pipette used for intracellular recording (Sakai et al. 1978a, b). HRP, a large macro-molecule of 40,000 MW, is injected intracellularly by pressure applications of 1-10 sec in sufficient amounts to permit visualization of the cell, its axonal-dendritic branchings, and the spinous processes of the dendrites. The location of a high proportion of the cell somas within the cortical layers is determined by a core biopsy procedure which also permits the survival of the preparation (Sakai et al. 1978a). The development of this technique represents a significant technological advance, promising extensive applications anatomically, neurophysiologically and neuropharmacologically.

4. The sampling distribution of neurons obtained by our intracellular, cortical recording procedure was investigated. The sample of HRP-identified neurons was found to be essentially equivalent to that seen in-situ (determined from Golgi-stained sections of these cortical regions). Seventy percent (70%) of penetrations were of cells in layers III and V, and 70% of penetrations were of pyramidal shaped cells. There was a slight tendency to over-sample neurons with extensive dendritic arborizations. As shown in Table II samplings of every major morphologically identified, in-situ cell type were obtained by our electrophysiological procedures (Sakai, et al., Brain Res., 1978).

C. Specific Objective 3 was to examine, intracellularly, the response of cortical neurons to delivery of an unconditioned stimulus (US) required as part of an associative pair for the production of conditioned learning.

1. The effect of presenting unpaired glabella tap on the excitability of cortical neurons was studied (Brons et al. 1978). Data from animals receiving the tap US were compared with data from naive animals given no US. The following preliminary results have been obtained:

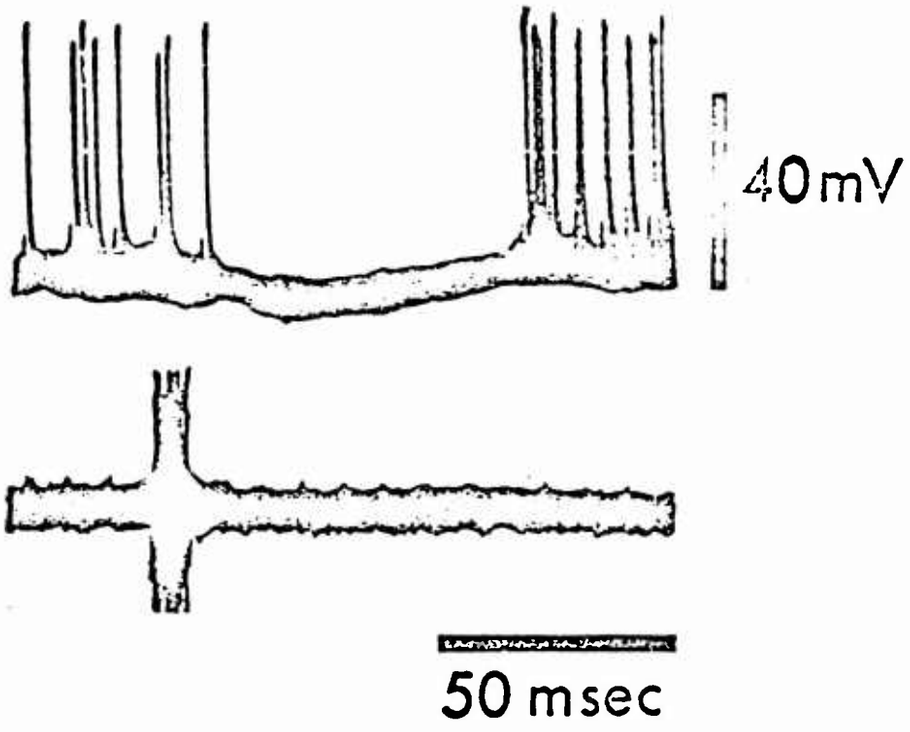
a. Levels of neuronal excitability to intracellularly injected current are higher, in cats receiving US, in cortical neurons projecting polysynaptically to the same facial musculature activated during the unconditioned response to the US (Table IIIA).

b. Levels of neuronal excitability to extracellularly injected current are lower in motor projective cells of cats receiving US (Table IIIB).

c. Most cells studied intracellularly show an IPSP in response to the US (Fig. 2).

d. The effects of US presentation on unit discharge were also assessed (Table IV). The predominant effect of US delivery on cortical neurons was a reduction in rates of discharge; however, on Day 2 of US presentations, a significant increase was observed in the numbers of cells responding with increased rates of discharge to US delivery. Evidence has been found for three US effects: 1) a transient increase in intracellular excitability lasting hours or days but not weeks, 2) a decrease in extracellular excitability of unknown duration and 3) an increase in the numbers of cells activated to discharge by the US from Day 1 to Day 2 of serial US presentation. (Brons, J. Doctoral Thesis, UCLA, 1979).

FIGURE 2



Suppression of spike activity and IPSP seen in a cortical neuron following delivery of glabella tap - US. Upper traces are superimposed intracellular records from a neuron of the coronal-pericruciate cortex; lower traces show the tap delivery.

2. Effects of low frequency stimulation of the pyramidal tract on cortical neurons were investigated. (Antidromic stimulation of the pyramidal tract has been used successfully as a US to produce conditioned learning by O'Brien and colleagues). Cortical cells activated antidromically responded predominantly with reduced excitability to intracellularly applied current. Cortical cells activated transsynaptically responded with increased intracellular excitability. Those cells failing to respond showed no change in excitability during the 5-15 minutes tested. (Tzebelikos and Woody, Brain Res. Bull., 1979).

A comparison of these results with those of high frequency stimulation (usually >50 HZ) reported by Bindman, et al., J. Physiol., 1979 is shown on Table V. As indicated, the direction of change is frequency dependent and differs between antidromically and transsynaptically activated units.

3. The response properties of penetrated neurons to injected polarizing currents were investigated and found to be normal. The accomodative response to ramp depolarizing currents was assessed; most responses were of the simple type rather than ceiling or minimal gradients, (cf. Koike et al., Exp. Br. Res., 1968a, b). Normal I-V plots and input resistance were also obtained. Several lines of evidence suggest that many cortical neurons have passive dendrites which serve the integrative process of neuronal information handling (Woody and Gruen, Brain Res., 1978).

D. Specific Objective 4 was to characterize cellular effects of possible chemical modulators of the excitability of cortical neurons:

1. Effects of acetylcholine (ACh) and cyclic GMP (cGMP) on membrane resistance were studied in groups of morphologically identified neurons. HRP was pressure injected into the cells after studying the effects of ACh. cGMP was also applied intracellulary by pressure injection. Pyramidal cells of layers V and VI responded to these agents with increases in resistance. The responsive neurons included those of layer V activated antidromically by PT stimulation.

A comparison of the results of pressure injected cGMP with those of intracellularly iontophoresed cGMP showed similar changes in resistance, but the increase in firing rate after the hyperpolarizing iontophoresis did not occur after pressure injection. The increase in firing rate following application of acetylcholine appears to be a separate effect of this agent, apart from that supported by cGMP as a second messenger. This effect may arise from excitation of surrounding neurons pre-synaptic to the one recorded or from other, direct conductance effects of acetylcholine binding at the neuronal receptors. (Swartz and Woody. J. Neurobiol., 1979; Woody et al., Soc. Neurosci. Abst., 1979).

2. Acetylcholine (ACh) and cyclic GMP (cGMP) appear to have similar effects on membrane resistance, ACh acting extracellularly. The membrane resistance is increased transiently by the effect of these agents alone and persistently by coupling these applications with cell depolarization sufficient to produce repeated discharge (Woody, et al., Brain Res., 1978).

It appears that neurotransmitters act in a dual manner in these cells, as in others, to convey information. One action, the direct "neurotransmitter effect" serves primarily to transmit information through the cell. The other action, the "modulatory effect" serves to control adaptation as a function of the information transmitted. The two actions are kept separated in the time -frequency domain by different time courses of involved biochemical pathways. See (Klopf, A.H., Brain Function and Adaptive Systems -- A Heterostatic Theory, AFCRL Dept., H133, 1972).

A third variable, depolarization induced discharge, serves to make the adaptation persistent rather than transient.

3. In a simulated neuron, consequences of active and passive dendritic membranes on information transfer properties were studied. With low rates of current spread, the neuron became a bistable (decisional) operator where spiking was enhanced if the threshold was below a certain level and suppressed if above that level. The enhancement was considerably more pronounced in neurons with passive than with active dendrites. With active dendrites a less intense input was needed to initiate somatic spiking (Levine and Woody, Biol. Cybernetics, 1978).

4. Prototype studies of the ability to morphologically identify types of neurons responding to ACh or cGMP were conducted using aceclidine, a cholinomimetic drug. Similar effects on membrane resistance were obtained with this drug, and the effects could be blocked by atropine (a muscarinic receptor blocker). A cell responding to aceclidine with an increased resistance was identified by injection of HRP as a pyramidal cell of layer VI (Swartz, et al., Proc. West. Pharm. Soc., 1973).

5. Effects on cortical neurons of intracellular application of cyclic AMP (cAMP) are being investigated. The cAMP is applied by pressure microinjection (0.1 mM solution in 4% HRP injected at 60-80 psi for 1-5 seconds). The following effects have been seen in HRP injected cells: a) decreases in firing rate, b) hyperpolarization, c) small decreases in membrane resistance, d) small decreases in excitability to intracellularly injected current. Pyramidal cells of layer V are among those showing these responses. Continued studies are in progress.

E. Specific Objective 5 was to investigate effects of hypothalamic reinforcement on adaptation of cortical neurons.

Effects on rates of conditioning of adding hypothalamic stimulation (HS) to classical application of CS (click) and US (glabella tap) were studied. The following are the preliminary results of pairing click CS with glabella tap (ISI, 340 ms) and HS (240 ms after tap). A hiss of intensity comparable to click CS was also presented 4 sec after HS as a discriminative stimulus (DS).

a. CRs emerged within 30-50 pairings or less (Fig. 3) instead of requiring the usual 100 or more pairings.

b. CRs were extinguished when click and hiss were presented alone.

c. A preliminary report of the results has appeared (Kim and Woody, Soc. Neurosci. in Abst., 1979).

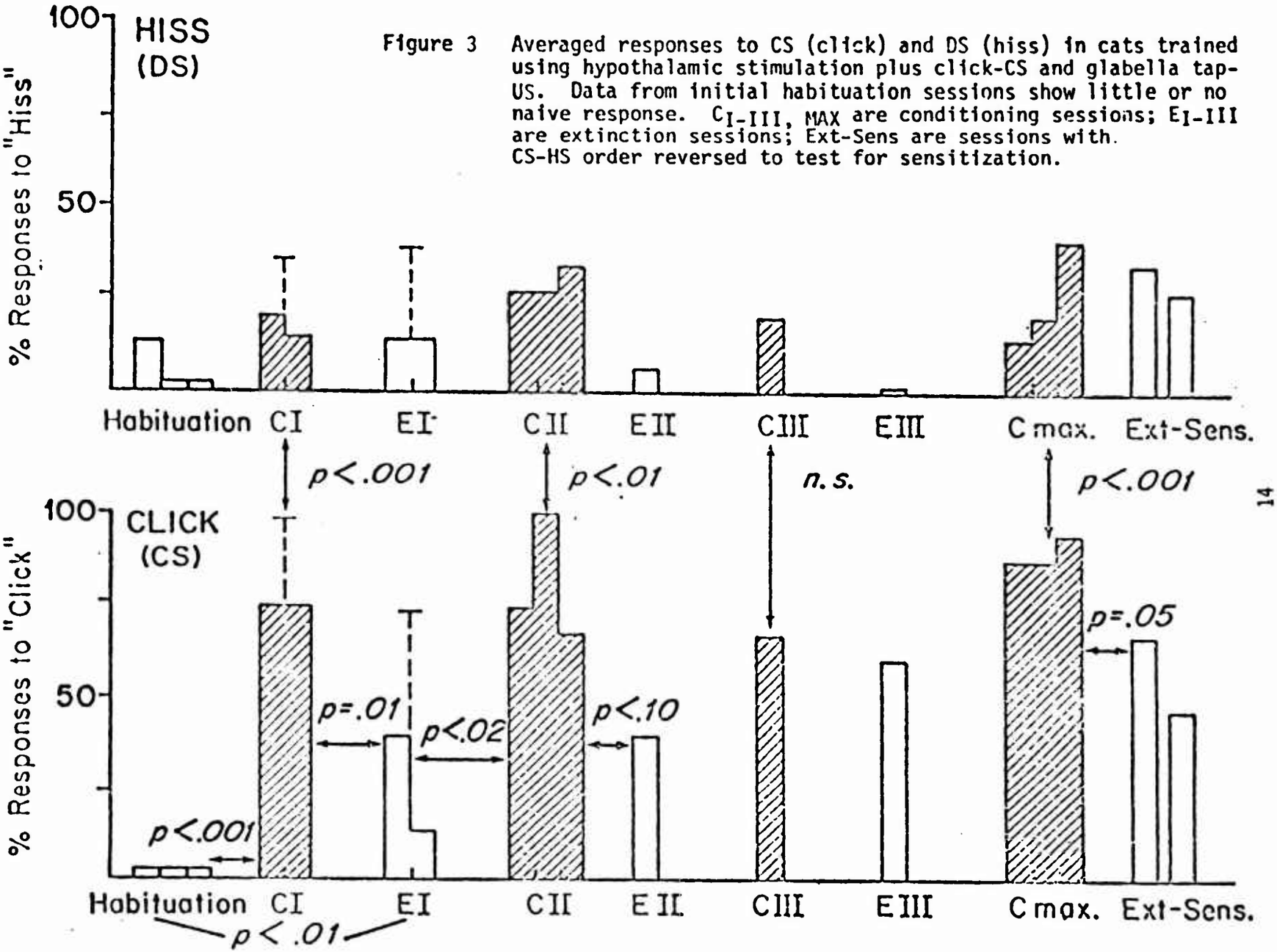


Figure 3 Averaged responses to CS (click) and DS (hiss) in cats trained using hypothalamic stimulation plus click-CS and glabella tap-US. Data from initial habituation sessions show little or no naive response. $C_{I-III, MAX}$ are conditioning sessions; E_{I-III} are extinction sessions; Ext-Sens are sessions with CS-HS order reversed to test for sensitization.

TABLE I

CONFERENCES AND WORKSHOPS

Adaptive Networks

Participants	J. Brons	D. Levine
	A.A. Buerger[1]	B. Swartz
	A.H. Klopf	C.D. Woody

Cybernetic Formulations Concerning Adaptive Networds

Participants	A.A. Buerger	M. Nahvi[2]
	A.H. Klopf	C.D. Woody
	D. Levine	

The Role Of Cyclic Nucleotides In Central Synaptic Function

Principal Speaker:	Floyd Bloom[3]	
Participants	J. Brons	H. Sakai
	J. Buchhalter	M. Sakai
	E. Gruen	B. Swartz
	P. Guttenberg	E. Tzebelikos
	A.H. Klopf	B. Wong
	D. [illegible]	C.D. Woody

Discussion of: "The Trans[illegible] Information And The Effect Of Local Feedback In The Theo[illegible] And Neural Networks" by A.M. Uttley[4]

Participants	A.A. Buerger[1]
	A.H. Klopf
	D. Levine
	C.D. Woody

Closed Feedback Loop Formulation

Principal Speaker	Mahmood Nahvi[2]	
Particpants	A.A. Buerger	D. Levine
	A.H. Klopf	C.D. Woody

Cellular Mechanisms Of Neural Control And Their Possible Application To Closed-Loop Reinforcement Of A Goal-Seeking Adaptive System

Participants	A.H. Klopf	B. Swartz
	M. Nahvi[2]	C.D. Woody

Table I continued

Calcium Ions And Cyclic Nucleotides As Universal Second Messengers

Principal Speaker:	M.H. Rasmussen[5]	
Participants	J. Brons	H. Sakai
	J. Buchhalter	M. Sakai
	A.A. Buerger	B. Swartz
	E. Gruen	E. Tzebelikos
	A.H. Klopf	C.D. Woody

Feedback Control Of Adaptations In Theoretical And Real Neurons

Workshop leader	A.M. Uttley[6]	
Participants	A.A. Buerger	M. Nahvi
	A.H. Klopf	C.D. Woody

Connections Between Artificial Intelligence And Theories In Neurosciences

Principal Speaker	M. Minsky[7]	
Participants	J. Brons	H. Sakai
	A.A. Buerger	M. Sakai
	J. Buchhalter	B. Swartz
	E. Gruen	E. Tzebelikos
	A.H. Klopf	C.D. Woody

Adaptive Networks, Neurophysiology And Testable Hypotheses Of Heterostatic Goal-seeking Adaptations

Participants	M. Arbib	N. Spinelli
	A.H. Klopf	C.D. Woody
	M. Nahvi	

Neurochemical Control of Neuronal Adaptation

Participants	Dr. T. Bartfai, University of Stockholm
	Dr. D. McAfee, City of Hope Medical Center
	Dr. D. Carpenter, AFFRI
	Dr. P. O'Lague, UCLA
	Dr. C. Woody, UCLA
	Dr. A. Barto, University of Massachusetts
	Dr. A.H. Klopf, USAF
	Dr. M. Sakai, UCLA
	Dr. M. Matsumura, UCLA
	Dr. H. Sakai, UCLA
	Dr. B. Swartz, UCLA
	Mr. J. Michkinsky, University of Massachusetts
	Mr. M. Poe, University of Massachusetts

Table I continued

1 - Assistant Professor, University of California, Irvine, California

2 - Chairman, Department of Electrical Engineering, Arya-Mehr University of Technology, Tehran, Iran

3 - Director, Arthur V. Davis Center for Behavioral Neurobiology, Salk Institute, San Diego, California

4 - Not Present

5 - Department of Internal Medicine, Yale University School of Medicine

6 - Laboratory of Experimental Psychology, University of Sussex, England

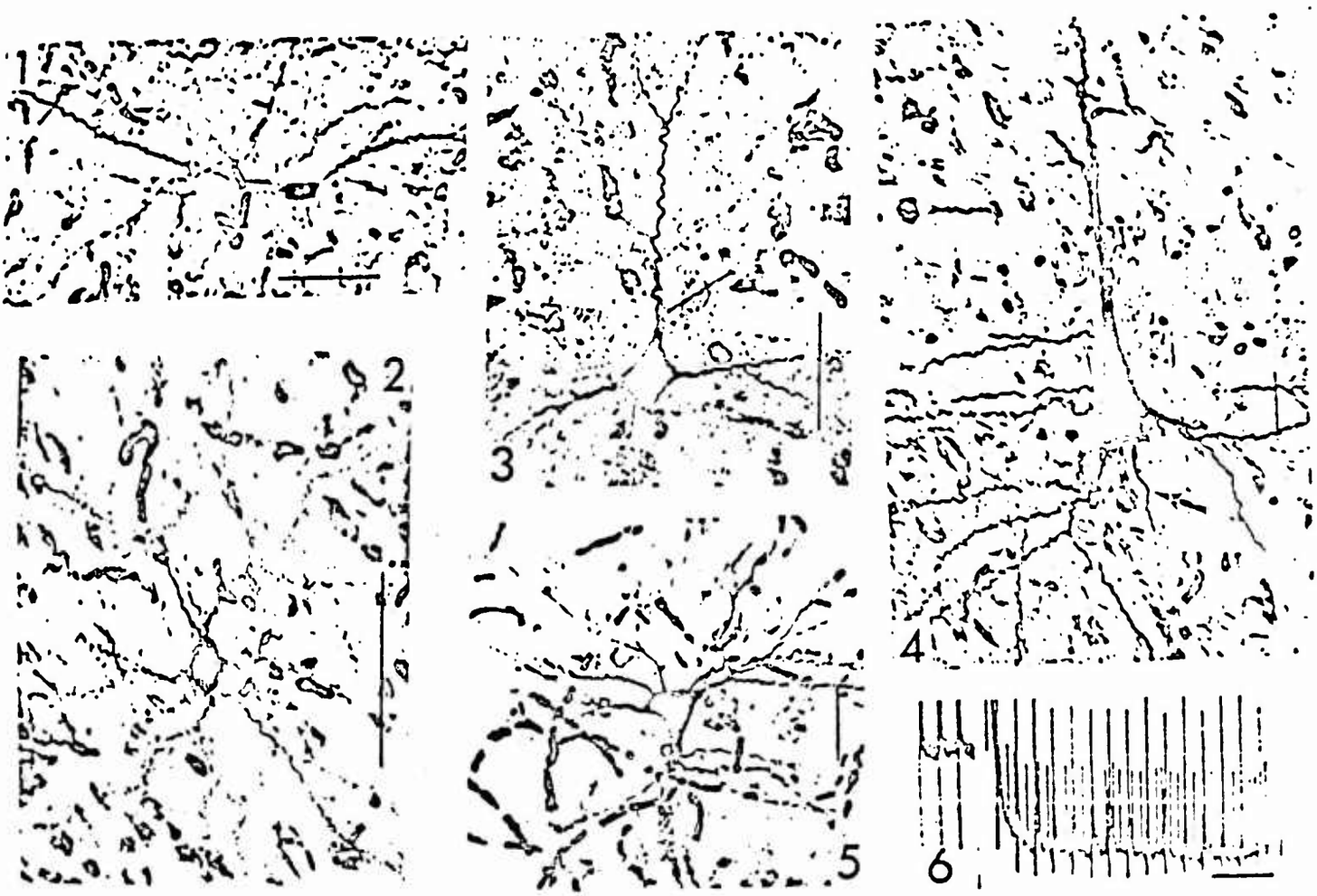
7 - Professor, Massachusetts Institute of Technology, Cambridge, Mass.

TABLE II

Distribution in different layers of the coronal-pericruciate cortex of different cell types penetrated intracellularly and injected with horseradish peroxidase.

Cell Type / Layer	Pyramidal				Stellate	Fusiform	
	Small (<15μm)	Medium (15-25μm)	Large (25-40μm)	Betz (>40μm)			
I					1		
II	1	1			3	1	
III	4	6	1		3		1
IV							
V		3	5	5	1		1
VI	1	3				1	
White Matter						2	
TOTAL	6	13	6	5	8	4	4

CELLS FROM TABLE II



Five different types of cells from the coronal-pericruciate cortex of the adult cat that were penetrated intracellularly and injected with horseradish peroxidase. 1) A horizontal cell located in the border area between layers I and II. Main dendrites protrude from either side of the soma. Thin spines were [illegible] on the distal dendritic branches. 2) A stellate cell [illegible] in layer II. Many main dendrites come off radially from the soma. Thin spines appeared on the dendrites after the primary branchings. 3) A small pyramidal cell located in layer III. The apical dendrite extended to layer II with several branchings in each layer. 4) A Betz cell located in layer V. Apical and basilar dendrites with many spines were seen. Axon is indicated by an arrow. 5) An inverted pyramidal cell located in layer VI. 6) Intracellular spike activity of cell (4) at penetration, the latter accompanied by a shift in baseline potential as illustrated. Long, vertic[illegible]rallel bars are artifacts from passing 0.5nA, 10 msec [illegible] across a Wheatstone bridge at 100 msec intervals. Action p[illegible]ials can be seen between pulse artifacts. The vertical bar is 20m.; the horizontal bar in 400 msec. All calibrations for pictures of the cells are 30μm.

TABLE III

Mean (± s.d.) levels of intracellularly (A) or extracellularly (B) injected current (nA) required to excite neurons of various facial motor projection in cats given glabella tap as US and in cats not given US. Projection is divided into that to eye, nose, both eye and nose and neither eye nor nose musculature. Numbers of cells studied are shown in upper right corners.

A.

	Eye	Nose	Both	Neither
US	0.6 ± 0.2 (10)	0.9 ± 0.5 (13)	0.7 ± 0.4 (14)	0.7 ± 0.4 (26)
Naive	1.0 ± 0.5 (17)	0.9 ± 0.6 (21)	1.0 ± 0.5 (23)	0.9 ± 0.4 (24)

X = values significantly different with $p < .05$, 1 tail Student t test

B.

US	5.0 ± 1.1 (18)	4.9 ± 1.0 (20)	5.0 ± 0.9 (31)	4.9 ± 0.9 (25)
Naive	3.7 ± 0.9 (19)	4.1 ± 1.2 (11)	3.7 ± 1.3 (18)	4.8 ± 1.1 (25)

⇕ = values significantly different with $p < .05$, 1 tail Student t test

Z = p = .06

TABLE IV

% of cells responding with increased discharge (E), decreased discharge (I) or failing to respond (UR) to glabella tap US on days 1 and 2 of repeated US presentations. Numbers of cells tested (n) are shown to the right.

	E	I	UR	n
Day 1	29%	36%	35%	55
Day 2	*55%	27%	18%	73

*difference significant, Chi sq. $p < .025$

TABLE V

Comparison of effects of high and low frequency PT stimulation on cortical neural excitability.

Low Frequency (Woody)

Antidromically activated:	excitability ↓
Transsynaptically activated:	excitability ↑
Unresponsive:	no change

High Frequency (Bindman, et al.)

Antidromically activated:	excitability ↑
Transsynaptically activated:	excitability ↓

Number of cells responding to low frequency stimulation:

	Excit ↓	Excit ↑	No change
Antidromic	14	9	11
Transsynaptic	6	21	15
Unresponsive	1	2	37

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16. Swartz, B.E. and Woody, C.D. Correlated effects of acetylcholine and cyclic guanosine monophosphate on membrane properties of mammalian neurocortical neurons. J. Neurobiol. 10: 465-488, 1979.

17. Woody, C.D., Sakai, H., Swartz, B., Sakai, M., and Gruen, E. Responses of morphologically identified mammalian, neocortical neurons to acetylcholine (ACh), aceclidine (ACec) and cyclic GMP (cGMP). Soc. Neurosci. Abstr. 5: 601, 1979.

18. Kim, H-J. and Woody, C.D. Facilitation of eye-blink conditioning by hypothalmic stimulation. Soc. Neurosci. Abstr. 5: 219, 1979.

19. Brons, J. and Woody, C.D. Changes in responsiveness to glabella tap among neurons in the sensorimotor cortex of awake cats. Soc. Neurosci. Abstr. 5: 314, 1979.

20. Sakai, H. and Woody, C.D. Identification of auditory responsive cells in the coronal-pericruciate cortex of awake cats. J. Neurophysiol. 44: 223-231, 1980.

21. Nahvi, M.J., Woody, C.D., Tzebelikos, E., and Ribak, C.E. Electrophysiological characterization of morphologically identified neurons in the cerebellar cortex of awake cats. Exp. Neurol. 67: 368-376, 1980.

22. Ribak, C.E., Woody, C.D., Nahvi, M.J., and Tzebelikos, E. Ultrastructural identification of physiologically recorded neurons in the cat cerebellum. Exp. Neurol. 67: 377-390, 1980.

23. Brons, J.F. and Woody, C.D. Long-term changes in excitability of cortical neurons after Pavlovian conditioning and extinction. J. Neurophysiol. 44: 605-615, 1980.

24. Woody, C.D. and Gruen, E. Effects of cyclic nucleotides on morphologically identified cortical neurons of cats. Proc. Int. Union Physiol. Sci. 14: 789, 1980.

LIST OF PROFESSIONAL PERSONNEL ASSOCIATED WITH THE RESEARCH EFFORT

Charles D. Woody, M.D.

L. Bindman, Ph.D.

J. Brons, Ph.D.

Haing-Ja Kim, Ph.D.

Michikazu Matsumura, Ph.D.

H. Sakai, M.A.

M. Sakai, Ph.D.

H. Tzebelikos, Ph.D.

(see attached abbreviated c.v.'s)

CURRICULUM VITAE

Name: Charles Dillon Woody

PII Redacted

[redacted]

[redacted]

Education:

1957 - A.B.	Princeton University
1962 - M.D.	Harvard Medical School

Positions Held:

1977 -	Professor, Anatomy, Psychiatry, and Biobehavioral Science, UCLA
1976 - 1977	Associate Professor in Residence of Anatomy, Psychiatry, University of California at Los Angeles
1971 - 1976	Associate Professor in Residence of Anatomy, Physiology, and Psychiatry, University of California at Los Angeles
1968 - 1971	Research Officer (permanent), Laboratory of Neural Control, NINDS, NIH, Bethesda, Maryland
1967 - 1968	Harvard Moseley Fellow with Dr. Jan Bures, Institute of Physiology, Czechoslovakian Academy of Sciences, Prague, Czechoslovakia
1964 - 1967	Research Associate, Laboratory of Neurophysiology, NIMH, NIH, Bethesda, Maryland
1963 - 1964	Research Fellow in Neurology, Harvard Medical School, Resident in Neurology, Boston City Hospital, Boston
1962 - 1963	Intern in Medicine, Strong Memorial Hospital, University of Rochester, Rochester, New York
1960 - 1961	NIH Post-sophomore Research Fellow at Stanley Cobb Laboratory, Massachusetts General Hospital, Harvard Medical School, Boston
1959 (summer)	Research Assistant, Communications Biophysics Group, Massachusetts Institute of Technology, Cambridge, Massachusetts

Honors and Fellowships:

M.D. Magna Cum Laude, Harvard Medical School, 1962
Leon Resnick Prize for Promise in Research, Harvard Medical School, 1962
Moseley Fellow, Harvard Medical School, 1967 - 1968
Nightingale Prize (Biol. Engng. Soc. & International Fed. Med. Biol. Engng. for best paper - International Journal: Med. Biol. Engng. 1966 - 1968) 1969.
Honorary Member, Pavlovian Institute, U.S.S.R., 1972
Representative of Society for Neuroscience to Physiological Reviews
Member, Brain Research Institute, and Mental Retardation Research Center, UCLA
Member, Neuroscience Committee supervising the UCLA Medical Center Graduate Program in Neuroscience
Bing Fellowship (Natl. Acad. Sci.) - Visiting scientist to USSR and Czechoslovakia, 1972
Chairman, session on "Brain and Behavior", FASEB Annual Meeting, 1973
Chairman, session on "Behavior and Conditioning", International Congress of Physiological Science, New Delhi, 1974
Invited Research Scientist and Lecturer at Kyoto University Primate Center, Japan; sponsored by Japan Society for the Promotion of Science, 1975.
Chairman, session on "Behavior and Neuroethology", FASEB Annual Meeting, 1977
Invited Panelist, Session on "Association Systems and Sensorimotor Integration", International Physiological Congress, Paris, 1977
Chairman, session on "Neurotransmitters", Soc. of Neuroscience, October, 1979.
Exchange Fellow, National Academy of Science, Prague, 1979.
Consultant to Publications Committee, American Physiologic Society, 1980
Grant Proposal Reviewer, NSF, NIH, ADAMHA, NIMH

Editorial Service

Member, Editorial Board, Physiological Reviews, 1974-1980

Editor, Soviet Research Reports, UCLA Brain Information Service

Member, Editorial Board, Brain Research Bulletin

Member, Board of Editorial Commentators, Current Commentary in Behavioral and Brain Sciences.

Member, Editorial Board, Neuroscience and Behavioral Physiology

Reviewer for above plus: Electroenceph. Clin. Neurophysiol., Physiol. Behav., J. Comp. Physiol. Psychol., Behav. Biol., J. Neurophysiol., Exper. Neurol., Exper. Brain Res., Brain Res., Science, Physiology and Behavior

CURRICULUM VITAE

Name: Dr. Lynn J. Bindman [redacted]

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[redacted]

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[redacted]

Education: South Hampstead High School for Girls, London

University College London, Department of Physiology 1957-1963

Degrees: BSc London 1960 Class Upper II
PhD London 1964 Physiology of the cerebral cortex

Posts held:

1963-1965 Honorary Research Assistant, Department of Physiology, UCL, Grant awarded by Medical Research Council

1965-1969 Assistant Lecturer (part-time) Department of Physiology, UCL

1969-1972 Research Associate (part-time) Department of Physiology, UCL. Grant awarded by Medical Research Council

1972- Lecturer, Department of Physiology, UCL

Membership of Societies

The Physiological Society - elected 1967
The Pharmacological Society - elected 1976
International Brain Research Organisation - elected 1978
Brain Research Association

Publications

Research:

LIPPOLD, O.C.J., REDFEARN, J.W.T. & WINTON, L.J. (1961). The potential level at the surface of the cerebral cortex of the rat and its relation to the cortical activity evoked by sensory stimulation. J. Physiol., 157, 7-9P

BINDMAN, L.J., LIPPOLD, O.C.J. & REDFEARN, J.W.T. (1961). The diffusion of γ-amino butyric acid within the mammalian cerebral cortex and the non-selective nature of its blocking action. J. Physiol., 160, 24-25P

BINDMAN, L.J., LIPPOLD, O.C.J & REDFEARN, J.W.T. (1962). The prolonged after-action of polarizing currents on the sensory cerebral cortex. J. Physiol., 162, 45-46P

BINDMAN, L.J., LIPPOLD, O.C.J. & REDFEARN, J.W.T. (1962). Long-lasting changes in the level of the electrical activity of the cerebral cortex produced by polarizing currents. Nature, 196, 584-585

BINDMAN, L.J., LIPPOLD, O.C.J. & REDFEARN, J.W.T. (1962). Variations in evoked potentials and potential gradients in the sensory cortex. Proc. XXII Int. Congr. Physiol. Sci., Leiden, Sept. 10-17

BINDMAN, L.J., LIPPOLD, O.C.J. & REDFEARN, J.W.T. (1962). The non-selective blocking of γ-amino butyric acid on the sensory cerebral cortex of the rat. J. Physiol., 162, 105-120

BINDMAN, L.J., LIPPOLD, O.C.J. & REDFEARN, J.W.T. (1963). Comparison of the effects on electrocortical activity of general body cooling and local cooling of the surface of the brain. Electroenceph.clin.Neurophysiol 15, 238-245

Continued on next page

Publications (Cont..)

BINDMAN, L.J., LIPPOLD, O.C.J. & REDFEARN, J.W.T. (1964). Relation between the size and form of potentials evoked by sensory stimulation and the background electrical activity in the cerebral cortex of the rat. J. Physiol., 171, 1-25

BINDMAN, L.J., LIPPOLD, O.C.J. & REDFEARN, J.W.T. (1964). The action of brief polarizing currents on the cerebral cortex of the rat (1) during current flow and (2) in the production of long-lasting after-effects. J. Physiol., 172, 369-382

BINDMAN, L.J. (1965) Long-lasting changes in the firing frequency of neurones in the rat cerebral cortex and radical potential gradients. J. Physiol., 179, 14-16P

BINDMAN, L.J. & BOISACQ-SCHEPENS, N. (1966). Persistent changes in the rate of firing of single, spontaneously active cortical cells in the rat produced by peripheral stimulation. J. Physiol., 185, 14-17P

BINDMAN, L.J. & BOISACQ-SCHEPENS, N. (1967). The relation between the 'spontaneous' rate of firing of neurones in the rat's cerebral cortex, their response to peripheral stimulation, and the duration of the after-discharge following stimulus. J. Physiol., 191, 7-9P

BOISACQ-SCHEPENS, N., & BINDMAN, L.J. (1967). Modifications durable, par la stimulation somatique, de la frequence de decharge spontanee de neurones corticaux chez le Rat: Differences entre les voies assurant l'excitation primair et l'activation prolongee. J. Physiologie (Paris), 59, 355-356

BINDMAN, L.J. & RICHARDSON, H.R. (1969) Persisting changes in the firing pattern of single cortical units responding at short latency to weak somatic stimuli in the anaesthetized rat. J. Physiol., 202, 53-55P

BINDMAN, L.J., BOISACQ-SCHEPENS, N. & RICHARDSON, H.R. (1971) "Facilitation" and "Reversal of response" of Neurones in the cerebral cortex. Nature New Biology, 230, 216-218

BINDMAN, L.J., LIPPOLD, O.C.J. & MILNE, A.R. (1976)., Long-lasting changes of post-synaptic origin in the excitability of pyramidal tract neurones J. Physiol., 258, 71-72P

BINDMAN, L.J., LIPPOLD, O.C.J., & MILNE, A.R. (1976). Prolonged decreases in excitability of pyramidal tract neurones. J. Physiol., 263, 141-142P

BINDMAN, L.J. & RICHARDSON, H.R. (1976). Enhancement of a phase of reduced firing in the response of spontaneiously active cortical neurones to somatic stimulation. J. Physiol., 263, 262-263P

BINDMAN, L.J. & MILNE, A.R. (1977) The reversible blocking action of topically applied magnesium solutions on neuronal activity in the cerebral cortex of the anaesthetized rat. J. Physiol., 269, 34-35P

BINDMAN, L.J., LIPPOLD, O.C.J. & MILNE, A.R. (1979) Prolonged changes in excitability of pyramidal tract neurones: a postsynaptic mechanism. J. Physiol., 286 ~~(in press)~~ 457-477

Publications (Cont...)

Book:

BINDMAN, L.J. & LIPPOLD, O.C.J. The Neurophysiology of the Cerebral Cortex. to be published (1980) Edward Arnold, London.

Connected with Teaching:

Book:

BINDMAN, L.J., JEWELL, B.R. AND SMAJE, L.H. (1978) Multiple choice Questions in Physiology, with answers and explanatory comments. Publ. Edward Arnold, London.

Audiotapes with booklets:

1) BINDMAN, L.J. (1978) Interpretation of experimental data in Physiology, based on a study of Calcium Metabolism. Board of Studies in Physiology, University of London. Distributed by the BLAT Centre for Health & Medical Education, BMA House, London.

2) SMAJE, L.H. & BINDMAN, L.J.(1975) Methods of Contraception. Board of studies in Physiology, University of London. Distributed by BLAT, BMA House, London.

3) BINDMAN, L.J. & DAVIES, M. (1979) The Autonomic Nervous System I Anatomy and Physiology, Audiotapes and booklets.
Board of Studies in Physiology, University of London. Distributed by the BLAT Centre for Health and Medical Education, BMA House, London.

Demonstration

At Physiological Society (in addition to scientific demonstrations listed among publications)

BINDMAN, L.J., JEWELL, B.R. & SMAJE, L.H. (1975) J. Physiol. 249, 19P
Display of self-instruction material for teaching Physiology.

Film

"Lung Surfactant" by L.J. BINDMAN & L.H. SMAJE, for use at UCL demonstrated at Phys. Society. 1975.

CURRICULUM VITAE

Name: John F. Brons

PII Redacted

[redacted]

Current Position: Postdoctoral Fellow, Department of Medical Psychology, University of Oregon Health Sciences Center, Portland, Ore.
Supervisors: Drs. J.H. O'Brien and R.D. Fitzgerald

Education:

1965-1970	University of California Santa Barbara	Major: Cell Biology Degree: B.A.
1972-1973	University of California Los Angeles	Interdepartmental Neuroscience Program
1973-1978	University of California Los Angeles	Department of Anatomy Degree: Ph.D.

Teaching Experience (at UCLA):

Teaching assistant for:	Medical Histology Dental Gross Anatomy Dental Neurology
Lecturer for:	Course: Basic and Quantified Neurophysiology Chairman: J. Segundo, M.D.

Relevant Employment and Training

1970-1972
Location: California Institute of Technology, Pasadena, Calif.
Position: Research Assistant
Supervisor: Dr. Marianne Olds
Responsibilities: Conduction of experiments on the cellular bases of appetitive conditioning and on the pharmacological basis of self-stimulating behavior.

1972-1975
Location: University of California, Los Angeles, Calif.
Position: Lab Assistant
Supervisor: R. Elul, M.D.
Responsibilities: Preparation and conduction of experiments on cell electrophoresis, electrophysiological recordings from neural tissue culture, and experimental epilepsy in cats.

1975-1978 Location: Department of Anatomy, University of California, Los Angeles
Graduate studies under the supervision of Dr. C.D. Woody.
Dissertation Title:
"Differences in the Excitability and Activity in Cortical Neurons After Pavlovian Conditioning, Extinction, and Presentation of the US Alone."

1978-1979 Location: Department of Psychiatry, University of California, Los Angeles.
Position: Postgraduate Research Neurophysiologist
Supervisor: Charles D. Woody, M.D.
Studies into long term changes in neural excitability associated with unconditioned blink reflexes.

1979- present Location: Department of Medical Psychology, University of Oregon Health Sciences Center, Portland, Oregon.
Position: Postdoctoral Fellow
Supervisors: Drs. J.H. O'Brien and R.D. Fitzgerald
Multiple unit studies of neural plasticity in brainstem sites associated with heart rate conditioning.

Publications:

Brons, J.F. and Woody, C.D.
Long term changes in the excitability of cortical neurons after Pavlovian conditioning and extinction.
(in press, J. Neurophysiol.)

Buchhalter, J.R., Brons, J.F., and Woody, C.D.
Changes in cortical neuronal excitability after presentations of a compound auditory stimulus. Brain Research 156(1978) 162-167.

Elul, R., Brons, J.F., and Kravitz, K.
Surface charge modifications associated with proliferation and differentiation in neuroblastoma cultures. Nature 258 (1975) 616-617.

Abstracts:

Brons, J.F. and Woody C.D.
Changes in responsiveness to glabella tap among neurons in the sensorimotor cortex of awake cats. Soc. Neurosci. Abstr. 5(1979)314.

Brons, J.F., Buchhalter, J.R., and Woody, C.D.
Decreases in excitability of cortical neurons to extracellularly delivered current after eyeblink conditioning, extinction, and presentation of US alone. Soc. Neurosci. Abstr. 4(1978)255.

Brons, J.F., Buchhalter, J.R., and Woody, C.D.
Increases in excitability of cortical neurons to injected intracellular current after eyeblink conditioning, extinction, and presentation of US alone. Fed. Proc. 37(1978)252.

Invited Lectureships

October 1976 — Mental Retardation Research Center (MRRC) Conference, Montecito, California.
Topic: Cortical excitability changes correlated with extinction of conditioned eyeblink reflexes.
Invited by: Dr. J. Villablanca

April 1977 — Armed Forces Radiobiology Research Institute, Bethesda, Md.
Topic: Changes in cortical excitability to intracellular and extracellular currents after eyeblink conditioning and extinction.
Invited by: Dr. D.O. Carpenter

November 1, 1977

Name: Haing-Ja Kim

PII Redacted

[redacted]

[redacted]

Sex: Female

[redacted]

Education:

B. S., 1967: Major; Physics: Minor; Mathematics: 1962-1967,
Seoul National University, Korea
1971-1972, Special student at Korea University, Korea,
Major; Psychology and Biology
1973 (January-June), Special student at the Western College, Ohio,
Major; Psychology and Biology
1973 (September-December), Graduate student at Bucknell University,
Major; Psychology

M. A., 1976: Major; Psychology: 1974-1976, Northwestern University

Ph. D., 1978: Major; Psychology: 1976-1978, Northwestern University
(to be received)
Major field; Neuroscience and Behavior

Teaching Experience:

1969-1971: Teaching assistant in Introductory Physics, Seoul National University, Korea

1975-1976: Teaching assistant in Introductory Psychology and Elementary Statistics, Northwestern University

Special Awards:

1973: University Scholarship, Western College & Bucknell University
1974-1975: University Fellowship, Northwestern University
1975-1976: Teaching Assistantship, Northwestern University
1976-1977: University Fellowship, Northwestern University
1977-1978: Research Assistantship, Northwestern University
1975-1977, Summer: Walter-Dill-Scott Fellowship, Northwestern University

Fields of Career Interest:

1) Mammalian mnemonic function
2) Neural mechanism underlying psychiatric disorders
3) Extrapyramidal motor function: Experimental Neurology
4) Pain mechanism
5) Neural and biochemical mechanism of sleep

References:

Aryeh Routtenberg, Professor of Psychology and Biological Sciences,
Cresap Neuroscience Laboratory, Northwestern University

J. Peter Rosenfeld, Professor of Psychology, Cresap Neuroscience Laboratory,
Northwestern University

Ronald Clavier, Professor of Anatomy, School of Medicine,
Northwestern University

Publications:

1. Kim, H.-J. and Routtenberg, A. Retention disruption following post-trial picrotoxin injection into the substantia nigra. Brain Research, 1976, 113, 620-625.

2. Routtenberg, A. and Kim, H.-J. The substantia nigra and neostriatum: Substrates for memory consolidation. In: L.L. Butcher (Ed.) Cholinergic-monoaminergic interactions in the brain. Academic Press Inc., New York and San Francisco, 1977 (in press).

Papers 'in preparation' for Publication:

1. Kim, H.-J. and Routtenberg, A. Significance of varied motor responses induced from the substantia nigra by intranigral drug injections.

2. Kim, H.-J. and Routtenberg, A. Dopamine cells and their dendritic configurations in the rat substantia nigra: A combined histofluorescence and thionin study of the identical sections.

Papers presented at Neuroscience Meetings:

1. Kim, H.-J., Miskit, D., and Routtenberg, A. Retention impairment of passive avoidance by post-trial injection of picrotoxin into the substantia nigra in rats. Neuroscience Abstracts, 1975, Vol. 1, pp 379.

2. Kim, H.-J. and Routtenberg, A. Retention deficit following post-trial dopamine injection into rat neostriatum. Neuroscience Abstracts, 1976, Vol. 2, pp 445.

CURRICULUM VITAE

Name: Michikazu Matsumura

PII Redacted

[redacted]

Current Position: Assistant Research Neurobiologist

Education

1969.4	Department of Biophysics	Major: Molecular Physiology
- 1973.3	Kyoto University	Degree: B. A.
1973.4	Primate Res. Inst.	Neurophysiology
- 1975.3	Kyoto University	Degree: Master
1975.4	Primate Res. Inst.	Neurophysiology
- 1978.3	Kyoto University	Degree: Ph. D.

Scholarship and Relevant Employment

1973 - 1974 Scholarship from Japanese Government
Location: Primate Res. Inst., Kyoto University
Supervisor: K. Kubota, M.D.
Responsibilities: Unit and field potential recording from monkey prefrontal cortex in awake and in anesthetized state.

1975 Inter-University Exchange Program
Location: Dept. Biological Engineering, Osaka University
Supervisor: N. Tsukahara, M.D.
Responsibilities: Intracellular studies in cat red nucleus and reticular formation after an ablation of cerebellar nuclei.

1976 - 1977 Scholarship from Japanese Government
Location: Primate Res. Inst., Kyoto University
Supervisor: K. Kubota,
Responsibilities: Intracellular recording from monkey motor cortex during voluntary movement.
(Doctoral Thesis)

1978 Post-Doctoral Fellow
Location: Primate Res. Inst., Kyoto University
Supervisor: K. Kubota
Responsibilities: Histological studies of cortico-cortical afferents to hand area of monkey motor cortex with horseradish peroxidase.

1978 - present
Assistant Research Neurobiologist
Location: Neuropsychiatric Inst., UCLA
Supervisor: C.D. Woody, M.D.
Responsibilities: Intracellular investigation of excitability changes in facial motoneurones in conditioned cat.

Publications (papers)

Matsumura, M.
Intracellular synaptic potentials of primate motor cortex neurons during voluntary movement.
Brain Research 163, (1979) 33 - 48

Matsumura, M. and Kubota, K.
Cortical projection to hand-area from post-arcuate area in Macaque monkeys: a histological study of retrograde transport of horseradish peroxidase.
Neuroscience Letters 11, (1979) 241 - 246

Abstracts

Matsumura, M. and Kubota, K.

(in Japanese) Visual evoked potentials of monkey prefrontal cortex: projection pathways from visual cortex.

J. physiol. Soc. Japan 38 (1976)

Matsumura, M. and Kubota, K.

Intracellular synaptic potentials of monkey motor cortex during visually-guided voluntary movement.

J. physiol. Soc. Japan 39 (1977) 347

Matsumura, M. and Kubota, K.

(in Japanese) PSP activities of monkey PT neurons preceding voluntary hand movement.

Oficial Report of 2nd Annual Meeting of Visual and Chemical Perception (1977)

Matsumura, M. and Kubota, K.

(in Japanese) Membrane properties of PT neurons in un-anesthetized Monkeys. Oficial Report of 3rd Annual Meeting of Visual and Chemical Perception. (1978)

Iwasaki, T., Matsumura, M. and Kubota, K.

(in Japanese) Unit activities of post arcuate neurons during Visual tracking task and their projections onto hand motor area.

J. EEG and EMG Japan (1978)

CURRICULUM VITAE

Name: Hiroko Sakai

PII Redacted

[redacted]

[redacted]

Education:

1970 - B.A. International Christian University
1972 - M.A. International Christian University
Ph.D.

Positions Held:

1974 - 1976	Assistant Research Microbiologist Institute for Developmental Research Aichi, Japan
1976 - 1979	Assistant Research Microbiologist Laboratory of Neurophysiology Mental Retardation Research Center UCLA
	Pre-Doctoral Fellow

Publications:

Kazuo Hara, Mimoto Hiroko, Masabumi Tanaka. Interocular transfer of visual discrimination learning sets by rhesus monkey. Annual report of the Primate Research Institute, Kyoto University 4: 45. 1974.

Yoshitaka Tamamaki and Hiroko Salai. Stability of the responses in the Sidiman avoidance learning. Annual report of the Institute for Developmental Research 4: 36. 1975.

Hiroko Sakai and Shigehiro Kiyono. The effect of intracortical microstimulation in VL of rats. Annual Report of the Institute for Developmental Research 4: 38-39. 1975.

Yoshitaka Tamaki and Hiroko Salai. Avoidance learning in Gunna rat. Annual report of Animal Psychology 25: 161. 1975.

CURRICULUM VITAE

Masaki Sakai
Department of Neurophysiology
Primate Research Institute
Kyoto University
Kanrin, Inuyama, Aichi
Japan 484
Phone: 0568-61-2891

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[redacted]

Degrees: 1969 Bachelor of Arts: Developmental Biology, Kyoto Univ.
1971 Master of Science: Neurophysiology
1974 Doctor of Science:(Eq. of Ph.D.)

Position: 1974-Instructor of Neurophysiology
Primate Research Institute, Kyoto Univ.

Publications:

Sakai,M.,Niki,H.,andKubota,K.,Simple monkey chair for neurophysiological studies. Advances in Neurological Sciences, 14,164-166 (1970) (In Japanese)

Kubota,K.,Niki,H., and Sakai,M.,Neurons of caudate and thalamic dorsomedial nuclei and delayed alternation performance in the rhesus monkey. J. Phsiol. Soc. Japan,33 p499 (1971)

Niki,H.,Sakai,M.,and Kubota,K.,Delayed alternation performance and unit activity of the caudate head and medial orbitofrontal gyrus in the monkey. Brain Research, 38,343-353 (1972)

Sakai,M.,and Forvath,F.,Unit activity of the prefrontal cortex and light-lever press reaction. J. Physiol. Soc. Japan,35, p514 (1973)

Sakai,M.,Prefrontal unit activity during visually guided lever pressing reaction in the monkey. Brain Research,81,297-309 (1974)

Sasaki,K.,Kawaguchi,S.,Oka,H.,Sakai,M., and Mizuno,M., Electrophysiological studies on the cerebellocerebral projections in monkeys. Exp. Brain Research 24, 495-507 (1976)

Sakai,M.,Unit activity in area 6 and the isometric voluntary contruction in rhesus monkeys. Ann. Meeting Jap. Physiol. Soc. (June 1976 Sendai)

PII Redacted

HENRI (ERRIKOS) TH. TZEBELIKOS, M.D. : CURRICULUM VITAE

PERSONAL: [redacted]

UNIVERSITY STUDIES:	1960-1966	University of Athens, School of Medicine (A marks)
MILITARY SERVICE:	1967-1969	Aug. 1967 to Jan. 1968 at the Dept. of Neurology, Larissa Military General Hospital Feb. 1968 to Jan. 1969 at the Dept. of Internal Medicine, same Hospital
DEGREES OBTAINED:	1966	M.D., University of Athens School of Medicine
	1971	Specialist in Neurology and Psychiatry, same University
	1974	Doctor of Medicine (in Physiology), same University, with honors
POSITIONS HELD:	1969-1971	Assistant in the Neurological Clinic, and Psychiatric Clinic, Departments of Neurology and Psychiatry, University of Athens, School of Medicine
	1973-1974	Registrar (for six months) in the 2nd Clinic, State Psychiatric Hospital, Tripolis, Greece, and then Director (for eight months) of the 1st Clinic, the same Hospital
	1970 - Present	Teaching Research Assistant, Department of Psyiology, Univ. of Athens, School of Medicine
RESEARCH ACTIVITIES:	1971-1975	At the Department of Physiology, Univ. of Athens, School of Medicine: (a) Study of the hormonal, pharmacological, and environmental control of the activity of phenylethanolamine-N-methyl transferase (PNMT) in the adrenal medulla of the rat. (b) Developmental study of PNMT, histamine-N-methyl transferase (HMT), and tryptamine-N-methyl transferase activity in the rat brain. Doctorate Thesis. (c) Hormonal control of PNMT activity in the rat brain during development. (d) Study of HMT activity in leucocytes of schizophrenic patients

TEACHING ACTIVITIES	1970-1975	Participation in organizing and explaining the student laboratory exercises in Physiology. Reviewing new developments in Neuro-biology during the Seminars of the lab.
	1974-1975	Lectures concerning the neural basis of behavior to the 2nd year medical students, Univ. of Athens School of Medicine.
	1974-1975	Teaching Human Physiology in the Midwife School "Marika Eliade", Athens.

ADDRESS: Department of Physiology
University of Athens
School of Medicine
Goudi, Athens (609)
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700 352

PUBLICATIONS:

1) Tzembelikos, E. A study of the activities of the N-methyl-transferases of norepinephrine, histamine, and tryptamine in the developing rat brain. Doctorate Thesis, Athens, 1973.

2) Savakis, Ch., Tzembelikos, Th. E., and Kouvelas, E. Environmental and pharmacological induction of PNMT in the rat adrenals. Presented at the Special Meeting of the Society for Endocrinology, Athens, 1974.

3) Kouvelas, E., Savakis, Ch., Tzembelikos, E., Bonatsos, E., and Mitrossillis, S. Developmental characteristics of PNMT and HMT in the rat brain. Accepted for publication by the Experientia (Switzerland).

4) Kouvelas, E., Tzembelikos, E., Savakis, Ch., Bonatsos, E., Machinis,G. and Mamatas, S. N-N dimethyltransferase of tryptamine in rat brain: Regional, subcellular distribution and developmental characteristics. Submitted for publication to Minerva Medica.

University of California, Los Angeles
Campus Veterinarian, IV-211 C.H.S.
Telephone: (213) 825-6240

Office Use Only
Application # _____ Project ID # _____
Effective _____ Expiration _____

APPLICATION FOR USE OF LABORATORY ANIMAL SUBJECTS

1. Applicant Charles D. Woody, MD Department NPI/MR
Phone: Office 825-0187 Home _____

2. Contact for animal problems & emergencies Charles D. Woody, MD
Phone: Office 825-0187 Home _____

3. Title of research or training project/activity Neurophysiological Research Supporting the Investigation of Adaptive Network Architecures

4. Starting Date 6/1/80 to 5/31/84 ☐ New ☒ Continuation ☐ Renewal ☐ Supplemental

5. ☒ Extramural funding, Acad. Senate, or Cal. Inst. for Cancer Res.: *Attach copy of proposal application.*

6. ☐ Intramural or other funding: *On cont. page outline project's objectives, animal purchasing & care budget.*

7. Animal Use Sites – building(s)/room(s) 58-147, 58-159, 57-384.

8. For animals held in laboratory more than 12 hours, does housing conform to DHEW Guide: ☒ Yes ☐ No

9. Species/Strain/Breed Cat Sex ___ Age/Weight Range _____

10. Total number for entire project/activity 20-40 per annum Expected Daily Population 12

11. ☐ Special procurement or processing needs: *Specify on continuation page.*

12. ☐ Procurement of dead animal material: *Answer questions 1-12 only and sign application.*

13. ☐ Short term use (up to 2 weeks) ☐ Long term use (more than 2 weeks) ☒ Both ☐ Breeding program

14. ☒ Standard housing, diet, sanitation & pest control ☐ Special needs: *Specify on continuation page.*

15. ☐ Project involves no pain or distress to animal subjects. *Refer to "Guiding Principles" #5.*

16. ☒ Project involves probable pain or distress to animal subjects. *Details of procedures on animals presented in:* ☐ *proposal application* ☐ *continuation page* ☒ *attached journal reprint*

17. ☒ Pain or distress relieved by anesthetic, analgesics, tranquilizers. *Use cont. page for add'l drugs.*
Cite: Drug(s) NA Pentobarbital Dosage 50mgm/kg Route IP

18. ☐ Pain or distress cannot be relieved. *Explain basis for exception on continuation page.*

19. ☐ Surgery: ☐ Nonsurvival ☒ Survival ☒ Aseptic Surgery ☐ Multiple surgeries on same animal

20. Procedure for sick/dead animals: ☐ Veterinary attention ☐ Discard ☒ Notify applicant

21. ☒ Euthanasia: Cite: drug(s) Nembutal Route IP
Cite other method(s) _____

22. ☐ Special veterinary & technical services required: *Specify on continuation page.*

23. ☐ Potential biological or radiation hazard to: ☐ Humans ☐ Animals *Describe on continuation page.*

USE CONTINUATION PAGE(S) FOR ADDITIONAL INFORMATION

2/1/76

UCLA STANDARD PROCEDURE 1110.1 - ATTACHMENT A

University of California, Los Angeles
Campus Veterinarian, W-211 C.H.S.
Telephone: (213) 825-6240

Office Use Only

Application # _____ Project ID # _____
Effective _____ Expiration _____

APPLICATION FOR USE OF LABORATORY ANIMAL SUBJECTS

A separate application must be completed and typewritten for each proposed project or activity utilizing animals.* Applications should be directed to the Campus Veterinarian for review, but can be sent after funding agency deadlines. However, an approved application is required for the University to accept extramural funds and before any animals can be ordered.

Applicant Charles D. Woody, MD

Phone: Office 825-0187 Home _____

Department/Division NPI/MR

Title of Research or Training Project/Activity Neurophysiological Research Supporting the Investigation of Adaptive Network Architectures

Estimated Starting Date 6/1/80 **Estimated Completion Date** 5/31/84

The undersigned attests to the attached information, and agrees to accept responsibility that all animal use in the above-titled project or activity will be in accordance with University, Federal, and other relevant policies and regulations. Any changes will be communicated to the Chancellor's Committee/Campus Veterinarian.

Signature Charles D. Woody 5/23/80
(Title) (Date)
Charles D. Woody, MD Professor of Anatomy and Psychiatry

*"Animal" *means any live or dead vertebrate.*

For Committee Use Only

☐ Application Approved: **Effective Date** _____ **Expiration Date** _____ ☐ Application Disapproved

Comments:

Signature _____
(Title) (Date)