

## **9.01: The Grand Scheme**

### **I. The Goals**

- We are trying to comprehend human nature as part of the natural world, by relating behavior to the nervous system.
- Goals of past scientists remain the goals of today (since Descartes, Gall, Broca, Wernicke, Cajal, Sherrington).
- In attempts to reach the basic goals, experimental work is fraught with special difficulties.
- Theoretical approaches to understanding brain & behavior, as well as modern experimental endeavors, take a “subsystems” approach, usually neglecting fundamental problems of understanding integration of the whole organism.
- But as theory advances beyond its current fledgling status, the basic goal will have some light shed on it.

### **II. The neuron**

- Primitive cellular mechanisms and neuronal specializations.
  - Membrane potentials and their conduction. Action potential.
  - Irritability; transduction.
  - Parts of a neuron in functional terms; cf. structural terms.
  - Secretion and the synapse. Neurotransmitters. Synapse types, variety.
  - Endogenous activity
  - (Movement: during development. See below.)

### **III. Evolution and basic structural / functional organization of CNS**

- First steps; S-R model with qualifications based on single-cell complexities.
- Chordates’ basic CNS plan: the neural tube.
- Elaboration of the neural tube, and why it occurred from an evolutionary perspective (Darwinian) – supported by evidence of comparative anatomy.
- Pre-mammalian plan of CNS: terms, basic parts and pathways, basic functions. Transection experiments; species differences. Lesion effects and the diaschisis phenomenon.
- Mammalian brain: elaboration of endbrain, especially neocortex with accompanying new pathways.

### **IV. Outline of mammalian neuroanatomy**

- Spinal cord organization and somatosensory pathways
- Hindbrain development and structural features, including cerebellum and pons.

- Midbrain: early links to forebrain; correlation center for spatial orientation and escape from predators; visceral representation and control of stability of the internal milieu (limbic midbrain areas).
- Forebrain: basic components and pathways:
  - Early influence and dominance of olfactory sense, then visual and other senses.
  - Diencephalon ('tweenbrain): especially hypothalamus and thalamus
  - Endbrain: olfactory at the beginning; evolutionary elaborations of corpus striatum and cortical structures
    - Limbic components vs neocortical components
    - MFB (medial forebrain bundle) vs LFB (lateral forebrain bundle) pathways as two major outputs of endbrain. (There are fibers oriented in the other direction also.)

## **V. Development and anatomical plasticity of CNS**

- Neurulation; phenomena of induction
- Proliferation of cells (ventricular layer; also subventricular layer in neocortex; external granular layer in cerebellum)
- Migration: three types discussed; probably all involve same basic mechanisms of motility: extension of a process and nuclear translocation within the process.
- Differentiation: growth of axons, dendrites, synapses; sculpting by cell death or loss of some axonal and dendritic branches.
- Axonal growth modes (two major ones)
- Phenomena of plasticity of maps and of connection specificity
- Factors affecting axon growth and its specificity
- Phenomena of regeneration and of collateral sprouting (in adults as well as developing organisms)

## **VI. Motor systems 1: Reflexes and Fixed Action Patterns (FAPs)**

- Reminder: reflexology and S-R model of behavior control
- Sherrington's spinal cats
- Withdrawal reflexes
  - Polysynaptic: proof in early electrophysiology experiment, that included a measure of synaptic delay.
  - Accompaniments: basic principle of reciprocal innervation.
- Stretch reflexes: the monosynaptic, muscle-to-muscle reflex arc.
  - Evolution and phylogeny
  - How it works. Alpha and gamma efferents; alpha-gamma co-activation.
  - Major function, considering the spring-like properties of muscles: control of muscle stiffness (tone)
- Propriospinal mechanisms: FAPs of cord; modules of limb movement control.
- Hindbrain:
  - Autonomic reflex regulation
  - Fixed action patterns: e.g., eyeblink, swallowing, emotional displays, etc.
- Plasticity in reflex connections

## **VII. Motor systems 2: Descending pathways and higher control**

- Clinical neurology and neuroanatomy: reflex model is common; pyramidal vs extrapyramidal systems (“for voluntary and involuntary movement”)
- Critique of these ideas
- The spatial layout of motor neurons and corresponding organization of interneurons, and of major descending pathways from brain to spinal cord
- Separation of two kinds of control (film: Lawrence and Kuypers):
  - Control of whole-body movements, especially axial muscles
  - Control of fractionated movements, especially of distal muscles (fingers)
- Cf. cerebellum; role in motor learning
- Corpus striatum:
  - Two major divisions dorso-ventrally; two major divisions mediolaterally.
  - Pathologies
  - Role in implicit learning
- Other motor systems
- (When do you stop calling it “motor”?)

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## **VIII. Rhythms of motor output and general activity**

### **IX. Visual system: anatomy and ablation studies**

### **X. Visual system: electrophysiological studies**

### **XI. Auditory system**

### **XII. Somatosensory system (cont'd) and pain**

### **XIII. Habituation and arousal systems**

### **XIV. Limbic system: mechanisms of drives, motivation**

### **XV. Higher functions, neocortex, and human nature**