Ch. 46 Sensory Receptors, Neuronal Circuits for Processing Information (Reading Homework Ch. 46)

- Sensory receptors detect touch, sound, light, pain, cold and warmth
- Basic mechanisms of how to change sensory stimuli into nerve signals and how the information conveyed by the signals is processed in the nervous system

◆ Types of sensory receptors and the sensory stimuli they detect
  - Table 46-1: sensory receptors
  - Five basic types
    - Mechanoreceptors
    - Thermoreceptors
    - Nociceptors (pain receptors)
    - Electromagnetic receptors
    - Chemoreceptors
  - Fig. 46-1: types of mechanoreceptors

- Differential sensitivity of receptors
  - How do two types of sensory receptors detect different types of sensory stimuli? – differential sensitivities
  - Each type of receptor is highly sensitive to one type of stimulus for which it is designed and yet is almost nonresponsive to other types of sensory stimuli
  - Modality of sensation – The Labeled line Principle
    - Modality of sensation: pain, touch, sight, etc
    - How is that different nerve fibers transmit different modalities of sensation? – Each nerve terminates at a specific point in the CNS.
    - Labeled line principle: the specificity of nerve fibers for transmitting only one modality of sensation

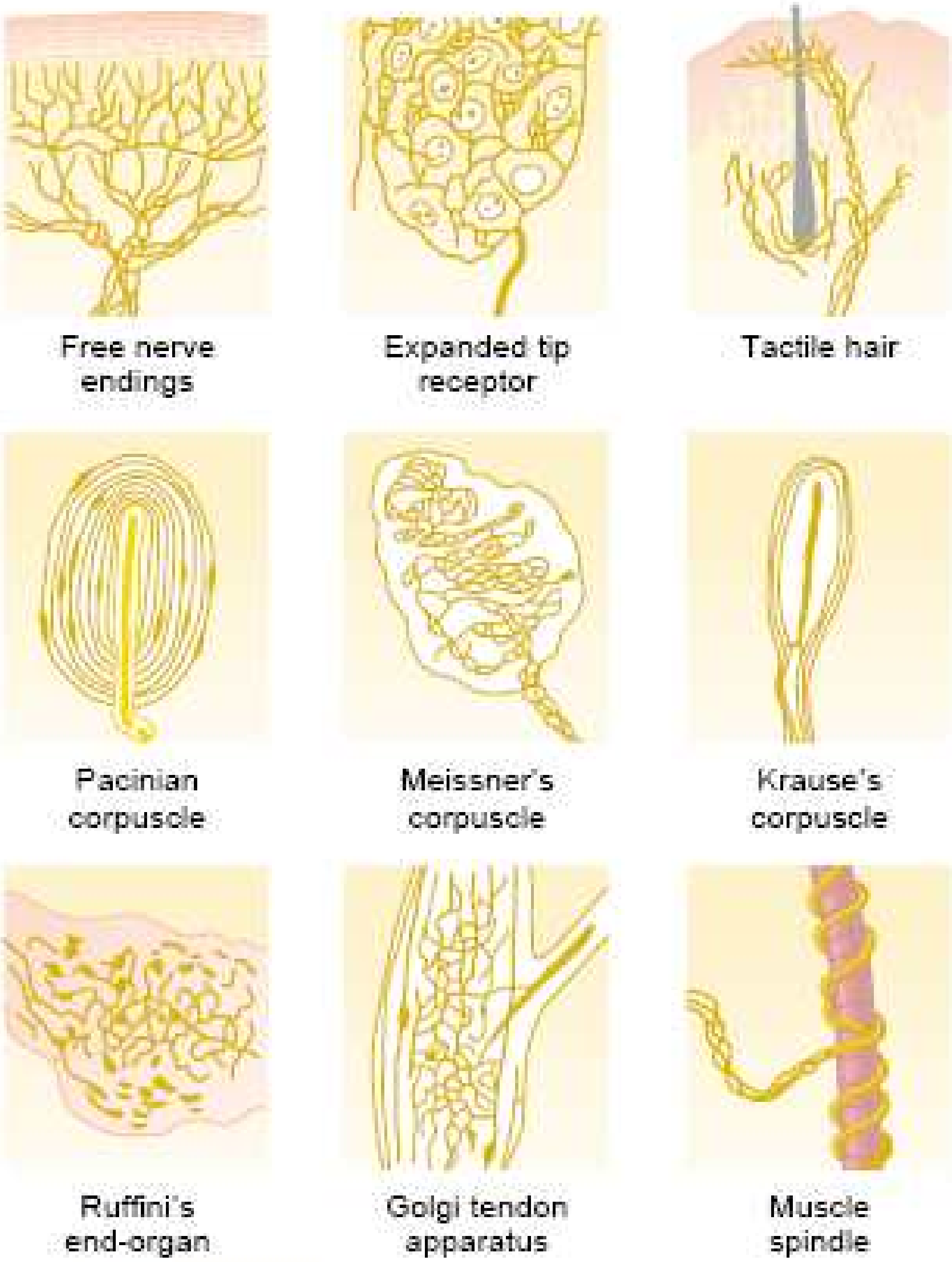


Figure 46–1

Several types of somatic sensory nerve endings.

Table 46–1

Classification of Sensory Receptors

- **I. Mechanoreceptors**
  - Skin tactile sensibilities (epidermis and dermis)
    - Free nerve endings
    - Expanded tip endings
      - Merkel's discs
      - Plus several other variants
    - Spray endings
    - Ruffini's endings
    - Encapsulated endings
      - Meissner's corpuscles
      - Krause's corpuscles
    - Hair end-organs
  - Deep tissue sensibilities
    - Free nerve endings
    - Expanded tip endings
    - Spray endings
      - Ruffini's endings
    - Encapsulated endings
      - Pacinian corpuscles
      - Plus a few other variants
    - Muscle endings
      - Muscle spindles
      - Golgi tendon receptors
  - Hearing
    - Sound receptors of cochlea
  - Equilibrium
    - Vestibular receptors
  - Arterial pressure
    - Baroreceptors of carotid sinuses and aorta
- **II. Thermoreceptors**
  - Cold
    - Cold receptors
  - Warmth
    - Warm receptors
- **III. Nociceptors**
  - Pain
    - Free nerve endings
- **IV. Electromagnetic receptors**
  - Vision
    - Rods
    - Cones
- **V. Chemoreceptors**
  - Taste
    - Receptors of taste buds
  - Smell
    - Receptors of olfactory epithelium
  - Arterial oxygen
    - Receptors of aortic and carotid bodies
  - Osmolality
    - Neurons in or near supraoptic nuclei
  - Blood CO_2
    - Receptors in or on surface of medulla and in aortic and carotid bodies
  - Blood glucose, amino acids, fatty acids
    - Receptors in hypothalamus

- ◆ Transduction of sensory stimuli into nerve impulses
- Receptor potentials: the change in potential at a receptor
  - Mechanisms of receptor potentials: excitation by
    - Mechanical deformation of the receptor: stretch and opening of ion channels
    - Application of chemical to the membrane
    - Change of the temperature
    - Electromagnetic radiation
  - Maximum receptor potential amplitude: 100mV
  - Relation of the receptor potential to action potentials: Fig. 46-2
  - Fig. 46-3
  - Fig. 46-4: relation between stimulus intensity and receptor potential
    - Amplitude increases rapidly at first, but then progressively less rapidly at high stimulus strength
    - It allows the receptor to be sensitive to very weak sensory experience and reach a maximum firing rate until the sensory experience is maximum.
    - The receptor have an extreme range of response

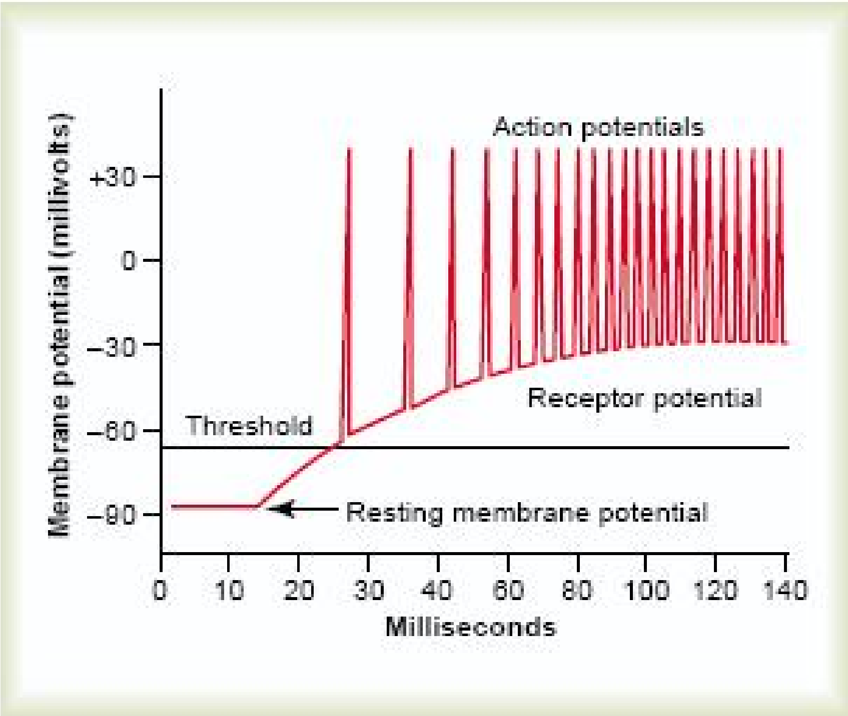


Figure 46–2

Typical relation between receptor potential and action potentials when the receptor potential rises above threshold level.

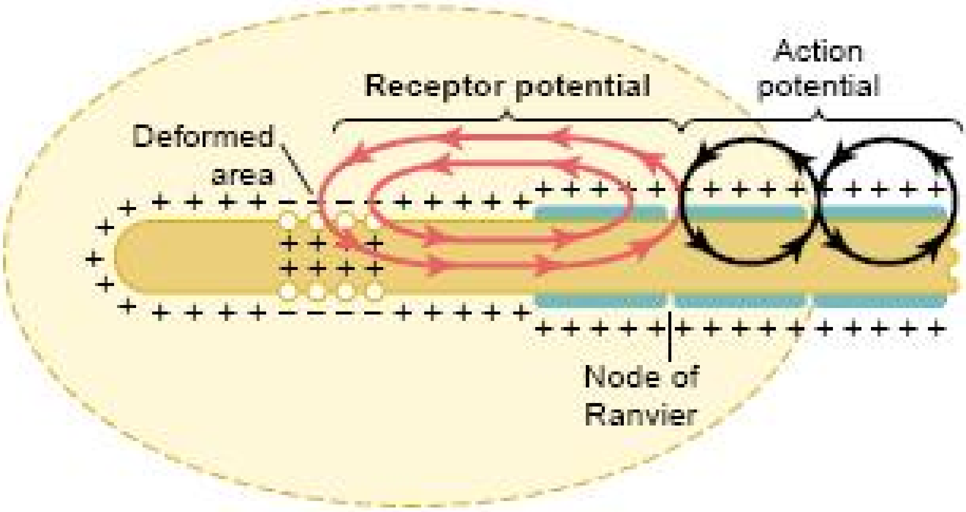


Figure 46–3

Excitation of a sensory nerve fiber by a receptor potential produced in a pacinian corpuscle. (Modified from Loëwenstein WR: Excitation and inactivation in a receptor membrane. Ann N Y Acad Sci 94:510, 1961.)

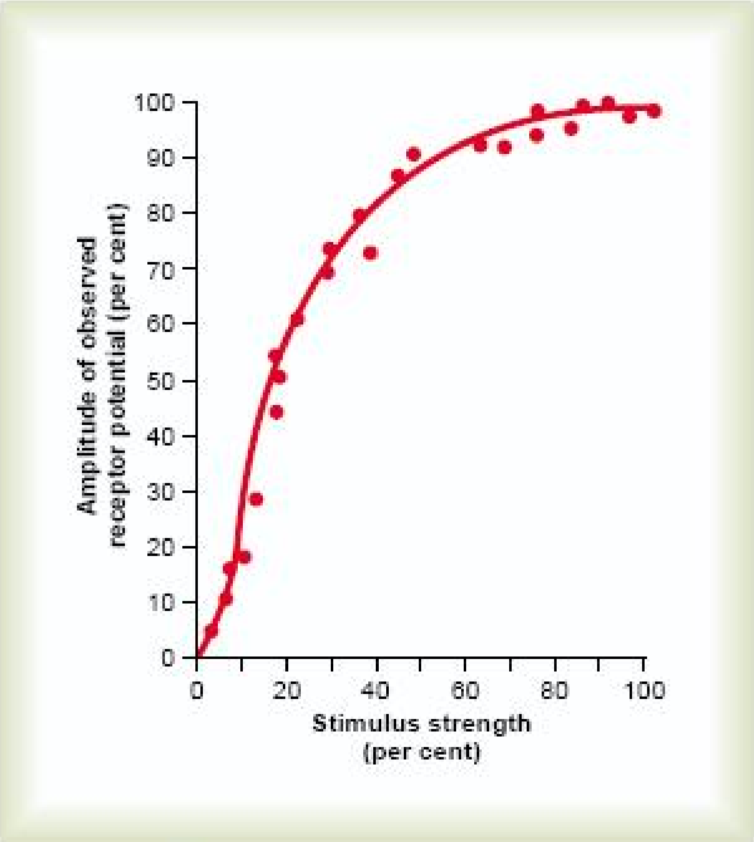


Figure 46–4

Relation of amplitude of receptor potential to strength of a mechanical stimulus applied to a pacinian corpuscle. (Data from Loëwenstein WR: Excitation and inactivation in a receptor membrane. Ann N Y Acad Sci 94:510, 1961.)

- Adaptation of receptors
  - Sensory receptors adapt either partially or completely to any constant stimulus after a period of time.
  - Fig. 46-5: Typical adaptation of certain types of receptors
  - Mechanisms by which receptors adapt
    - Receptor potential appears at the onset of stimuli, not after
    - Accommodation
  - Tonic receptors: slowly adapting receptors can continue to transmit information for many hours
  - Rate receptors (movement receptors or phasic receptors): Rapidly adapting receptors detect changes in stimulus strength
  - Importance of rate receptors – predictive function
- Physiological classification and functions of nerve fibers (Fig. 46-6)
- Spatial and Temporal Summation
  - Spatial summation
    - Receptor field
    - Fig. 46-7
    - Stronger stimulus, more fibers
  - Temporal summation
    - Fig. 46-8

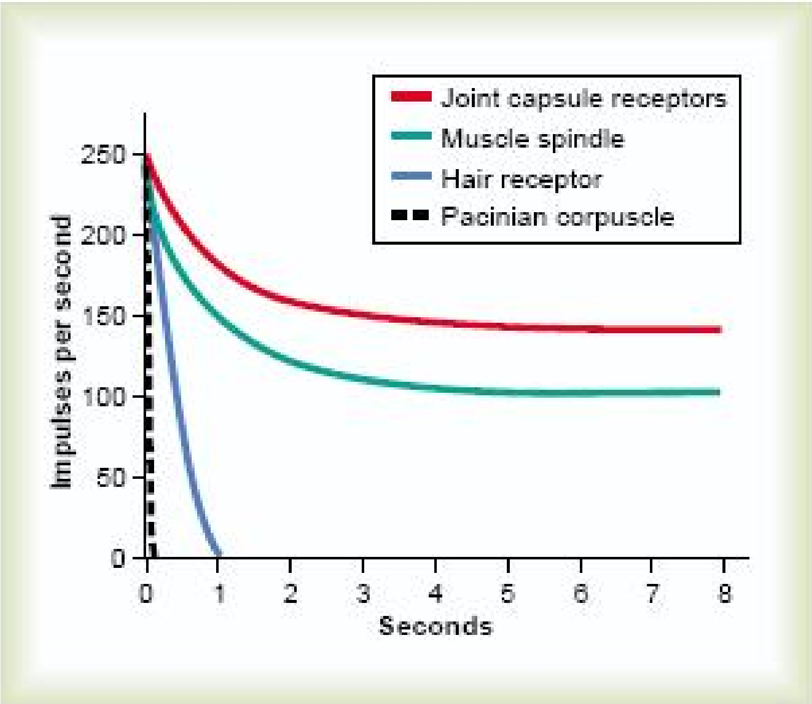


Figure 46–5

Adaptation of different types of receptors, showing rapid adaptation of some receptors and slow adaptation of others.

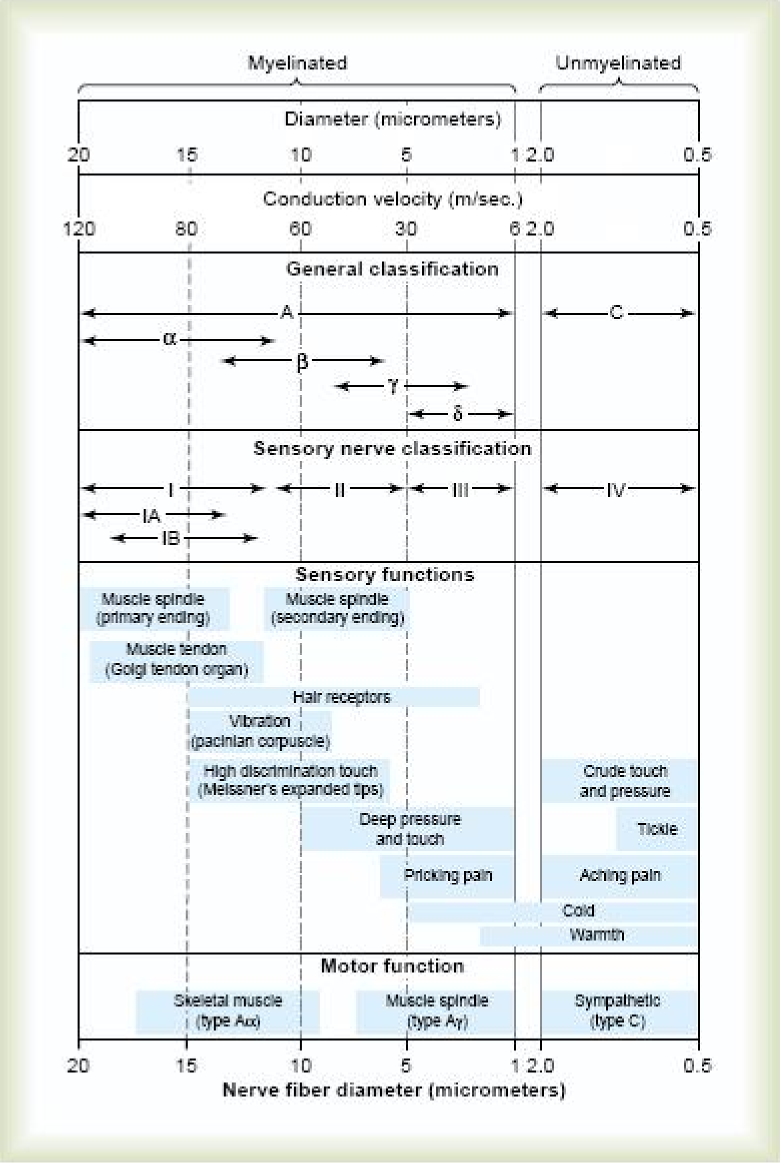


Figure 46–6

Physiologic classifications and functions of nerve fibers.

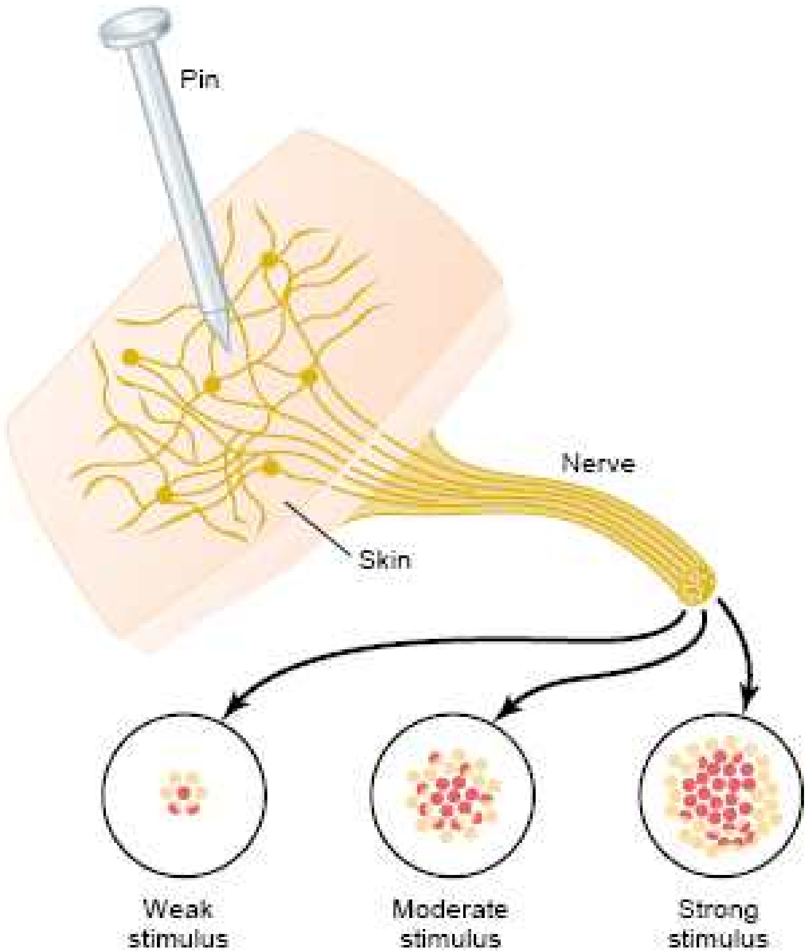


Figure 46–7

Pattern of stimulation of pain fibers in a nerve leading from an area of skin pricked by a pin. This is an example of *spatial summation*.

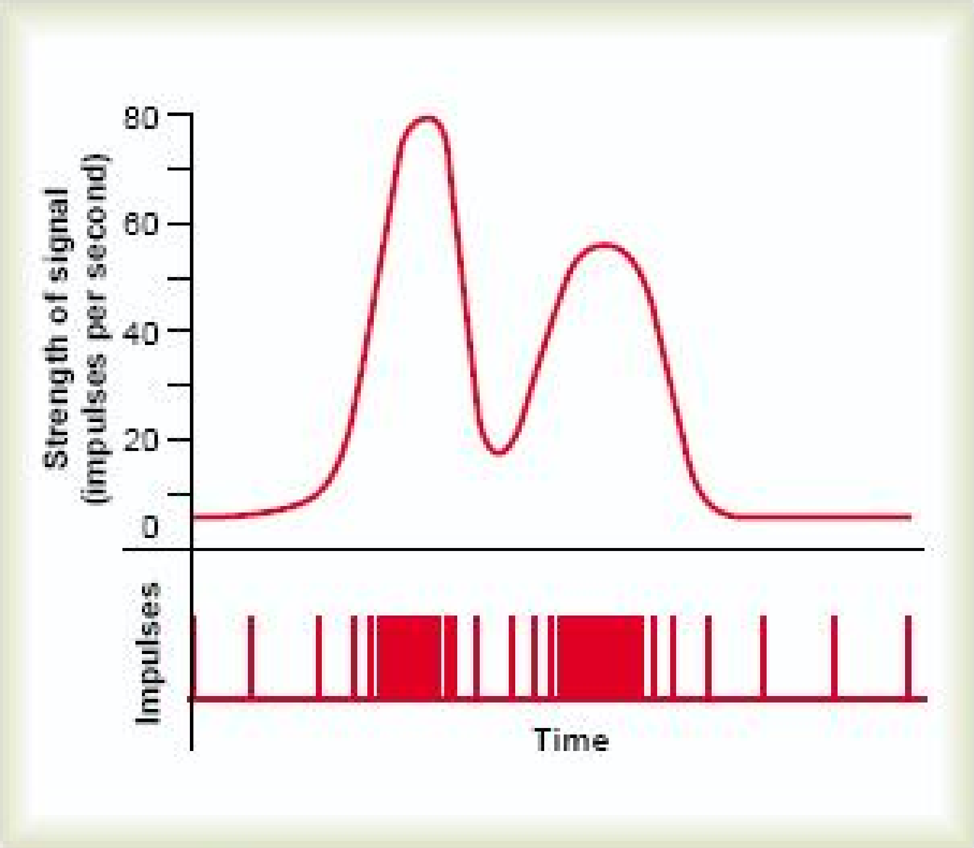


Figure 46–8

Translation of signal strength into a frequency-modulated series of nerve impulses, showing the strength of signal (*above*) and the separate nerve impulses (*below*). This is an example of *temporal summation*.

- Transmission and processing of signals in neuronal pools
  - Neuronal pools
  - Each pool has its own special characteristics
  - Relaying of signals through neuronal pools
    - Stimulatory field
    - Fig. 46-9
    - Excitatory stimulus – suprathreshold stimulus
    - Facilitated – subthreshold
    - Inhibitory zone
    - Fig. 46-10
  - Divergence of signals: Fig. 46-11
  - Convergence of signals: Fig. 46-12
  - Inhibitory circuits: Fig. 46-13
  - Reverberatory (Oscillatory) circuits: Fig. 46-14

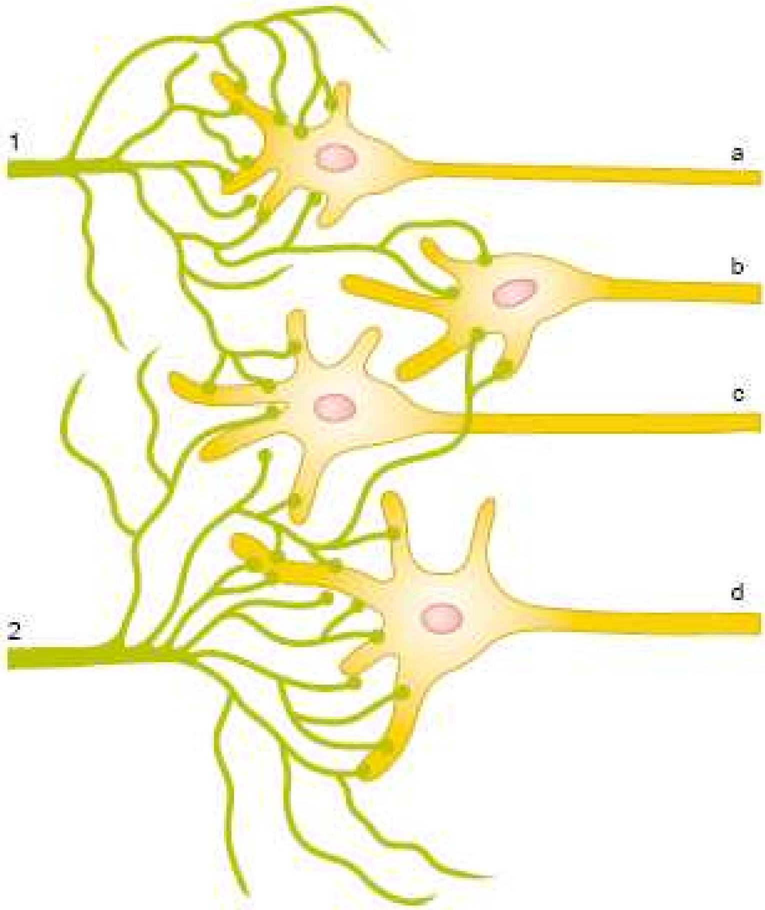


Figure 46–9

Basic organization of a neuronal pool.

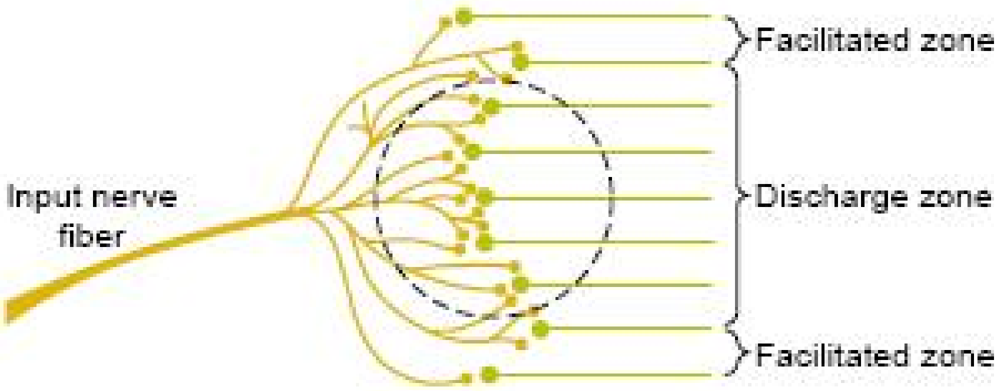


Figure 46–10

"Discharge" and "facilitated" zones of a neuronal pool.

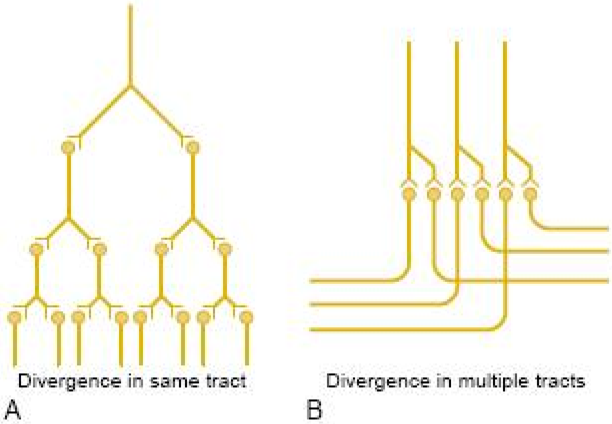


Figure 46–11

"Divergence" in neuronal pathways. *A*, Divergence within a pathway to cause "amplification" of the signal. *B*, Divergence into multiple tracts to transmit the signal to separate areas.

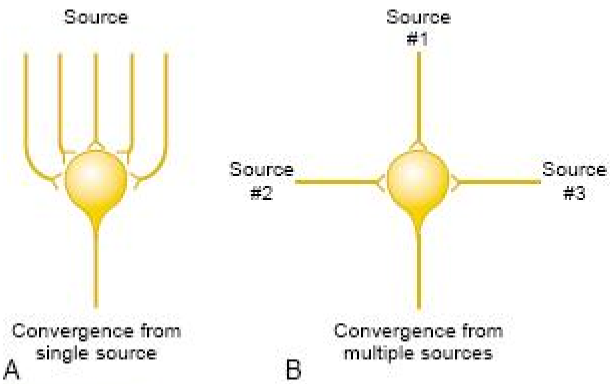


Figure 46–12

"Convergence" of multiple input fibers onto a single neuron. *A*, Multiple input fibers from a single source. *B*, Input fibers from multiple separate sources.

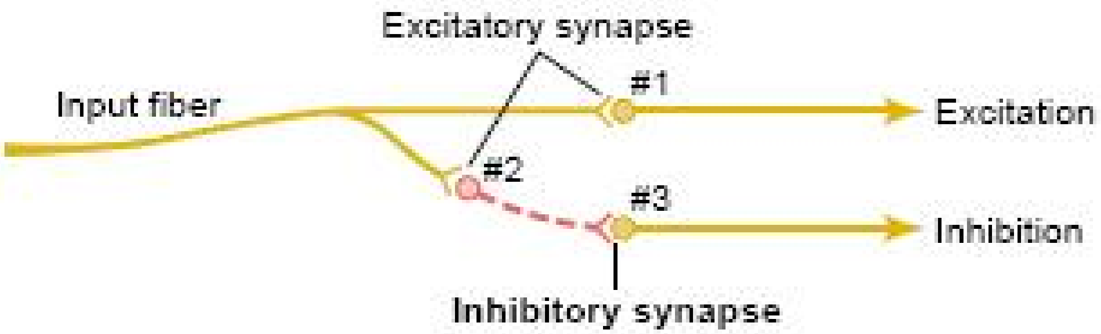


Figure 46–13

Inhibitory circuit. Neuron 2 is an inhibitory neuron.

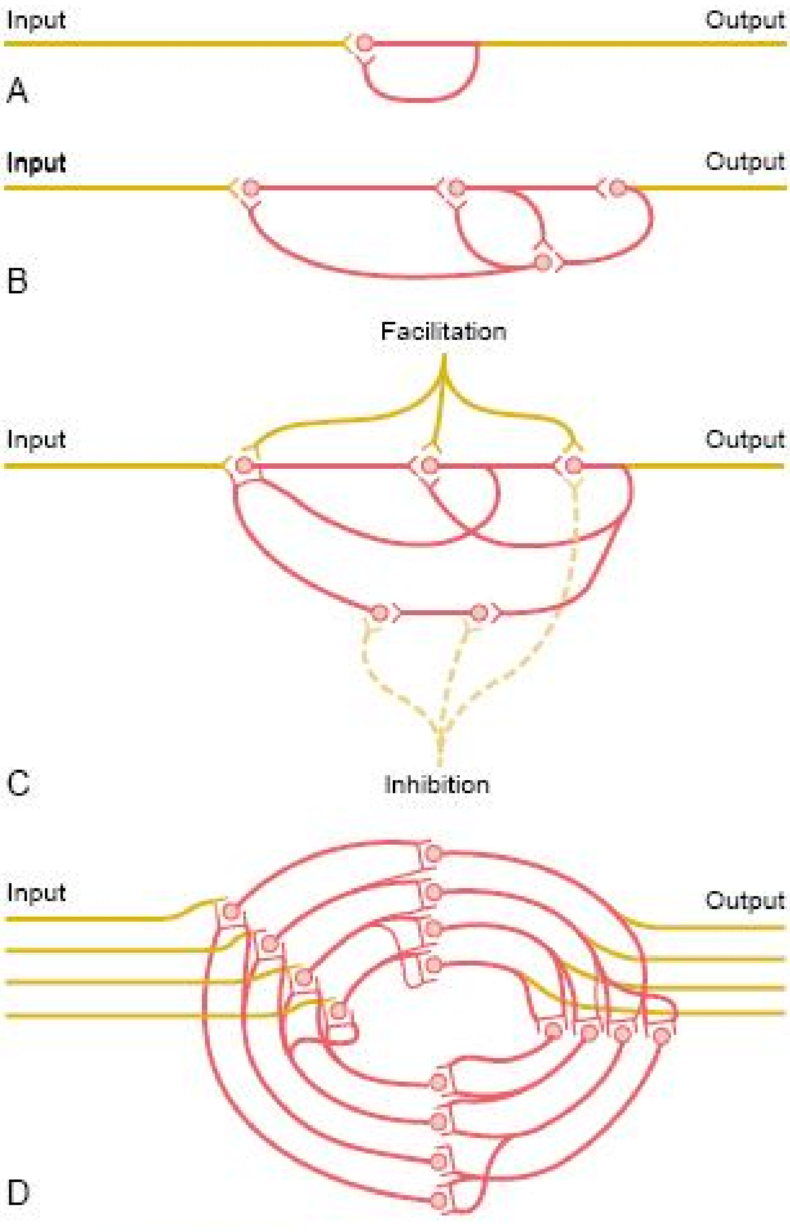
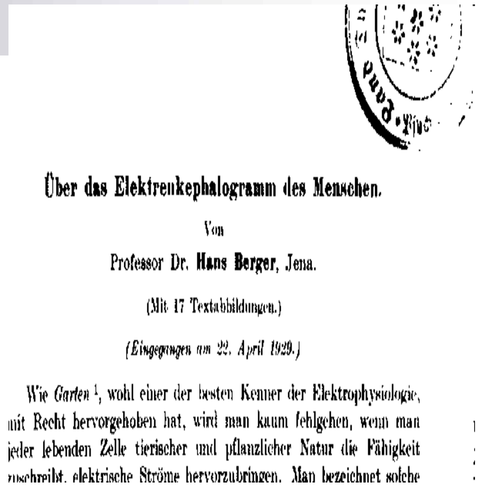


Figure 46–14

Reverberatory circuits of increasing complexity.

Instruments: EEG



Über das Elektrenkephalogramm des Menschen.

Von

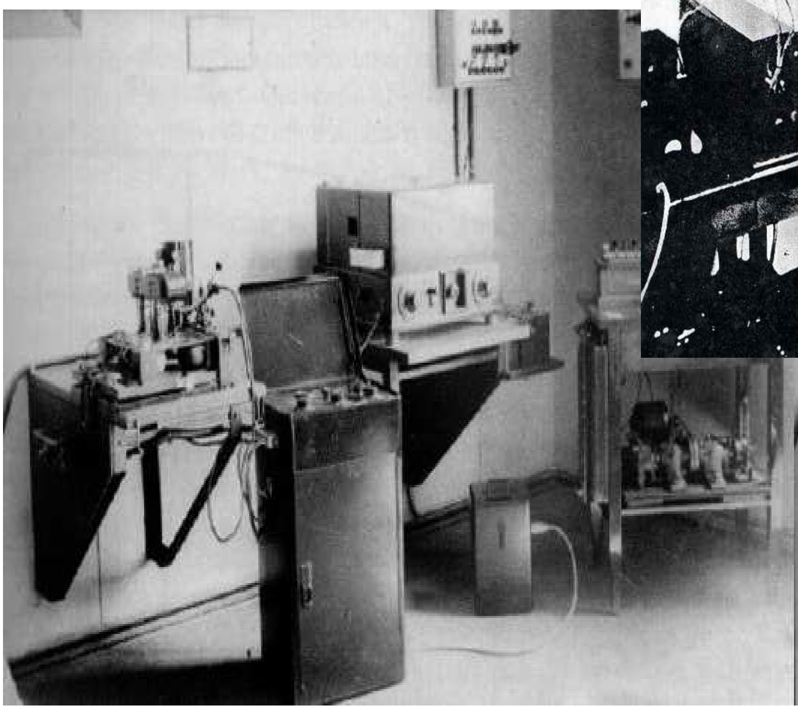
Professor Dr. **Hans Berger**, Jena.

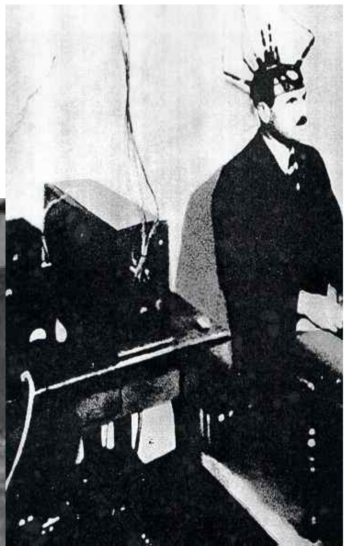
(Mit 17 Textabbildungen.)

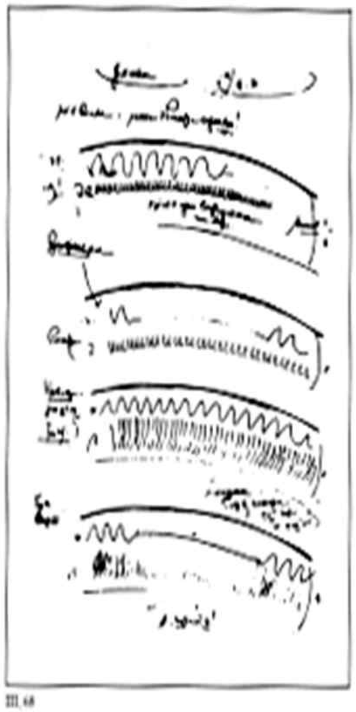
(Eingegangen am 22. April 1929.)

Wie *Garten*[1], wohl einer der besten Kenner der Elektrophysiologie, mit Recht hervorgehoben hat, wird man kaum fehlgehen, wenn man jeder lebenden Zelle tierischer und pflanzlicher Natur die Fähigkeit zuschreibt, elektrische Ströme hervorzubringen. Man bezeichnet solche

- Hans Berger (1929)
- Reasonably low-cost
- Widely used in clinical practice + Neuropsychology research units







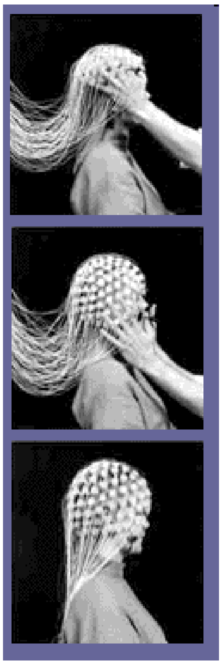
EEG Instrumentation

- Electrode Board = load plug-in box or input box
- Electrode Selectors => montage
- Differential Amplifiers
- Filters
- Penmotors
- Chart Drive
- Power Supply
- Calibrator
- Electrodes (Sensors)
- Electrolytes, Gels, and Pastes

* WWW Neuro Scan Labs

Instruments: EEG

MicroMed



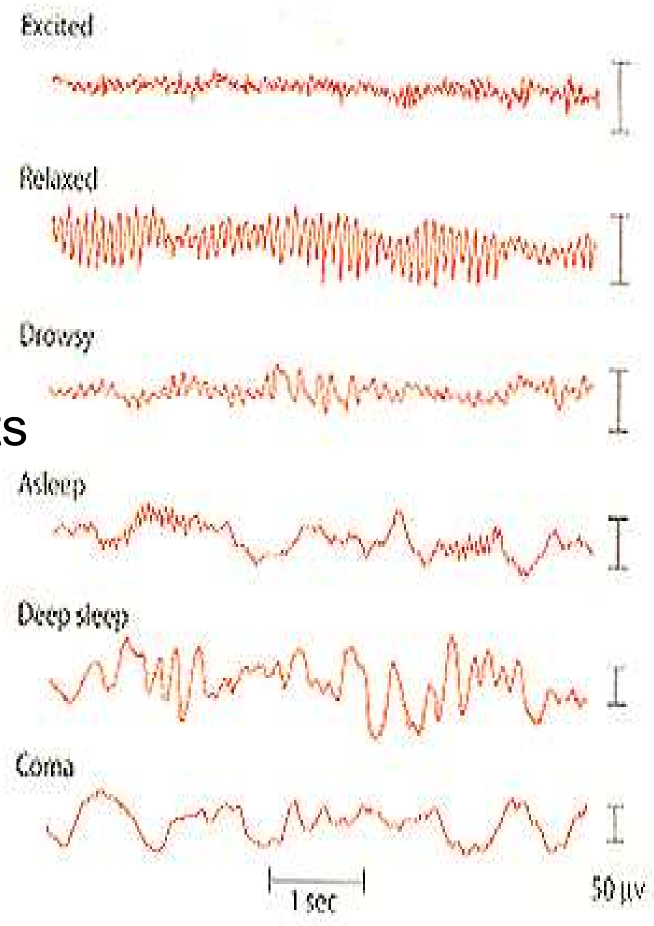
Electrical
Geodesics

NeuroScan

Spontaneous Brain Activity

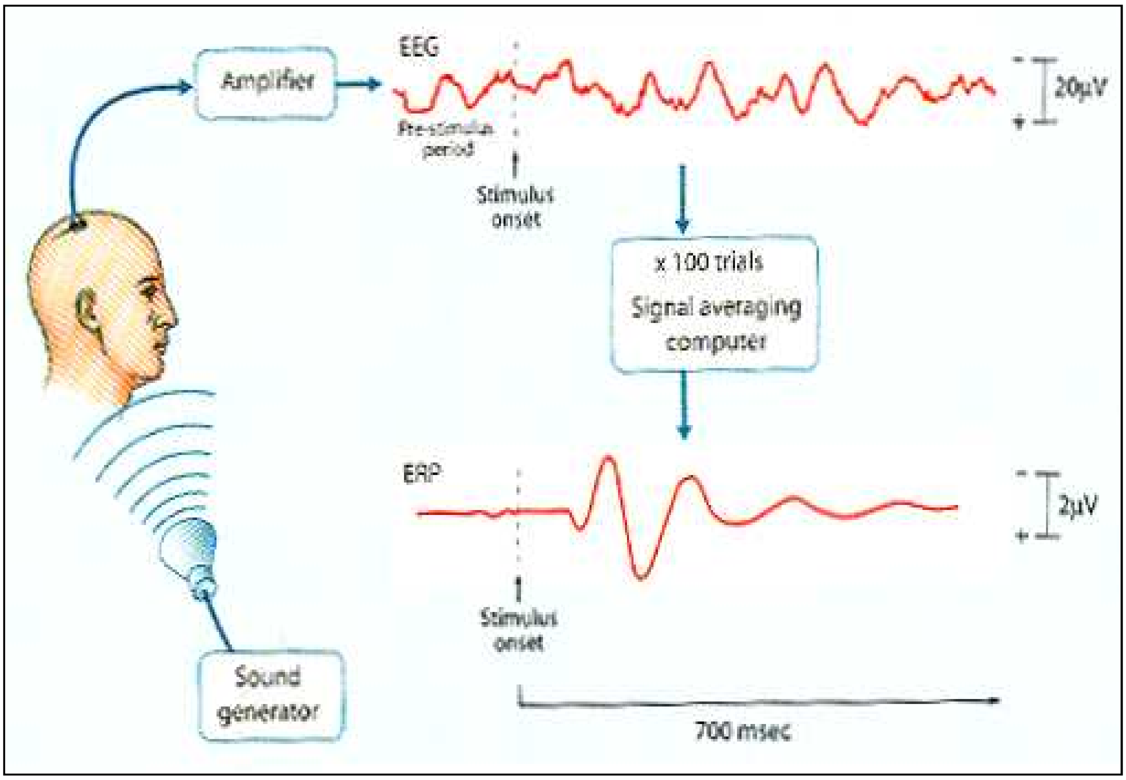
Oscillations of electrical activity which are thought to be the average across thousands of cells

- Alpha Rhythm: 8-13Hz
  - Relax & meditation
- Beta Activity: 13-35Hz
  - Alert or anxious
- Theta Activity: 3-7Hz
  - Abnormal in awake adults
- Delta Activity: <3Hz
  - Slow-wave sleep

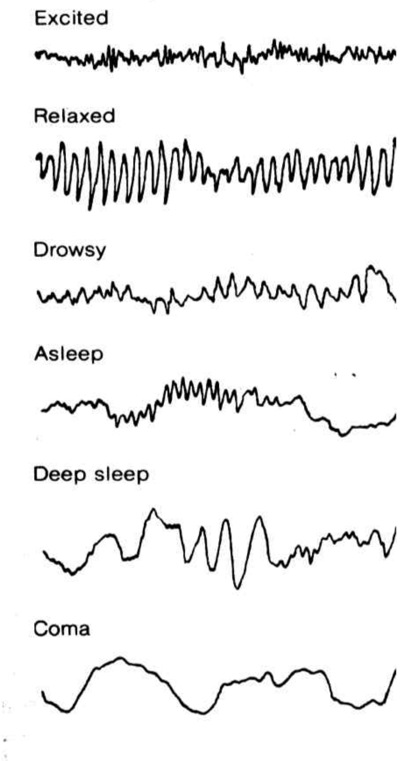


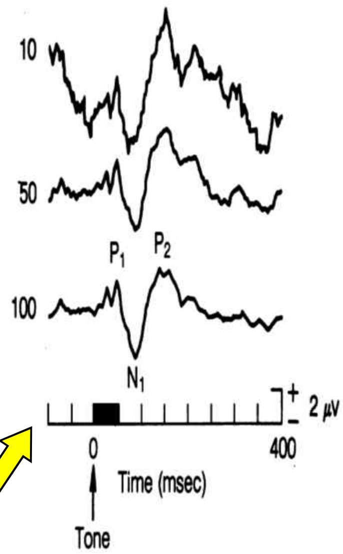
Event-related Evoked Potentials

An evoked potential is essentially the same kind of recording, but with larger change of electrical activity which are triggered by a stimulus.



An electroencephalogram (EEG) records much smaller oscillations of electrical activity which are thought to be the average across thousands of cells.





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Brain Mapping with EEG and fMRI