Sensory Systems

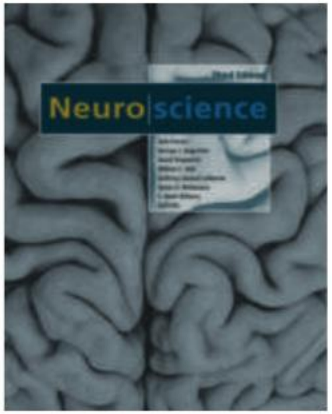
Overview

From sensation to perception...

Topics I	Topics II
Introduction	Synaptic Transmission
Electrochemical Gradients	Electrophysiology Techniques
Passive Membrane Properties	Basic Circuits (Spinal Cord)
Action Potential	Sensory Systems Overview
Voltage-Gated Ion Channels	Synaptic Plasticity
Ligand-Gated Ion Channels	Recapitulation

Study Material

- NEUROSCIENCE Third Edition
  - Dale Purves
- Unit II
  - Pages 189-337



THE COVER
Dorsal view of the human brain.
(Courtesy of S. Mark Williams.)

NEUROSCIENCE: Third Edition

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Aims for this Lecture

- Know the main sensory systems and their transducers.
- Understand sensation as an active process. We are not video cameras with smell detection tracks…..
- Learn about salient feature extraction along the processing pathway in different systems.

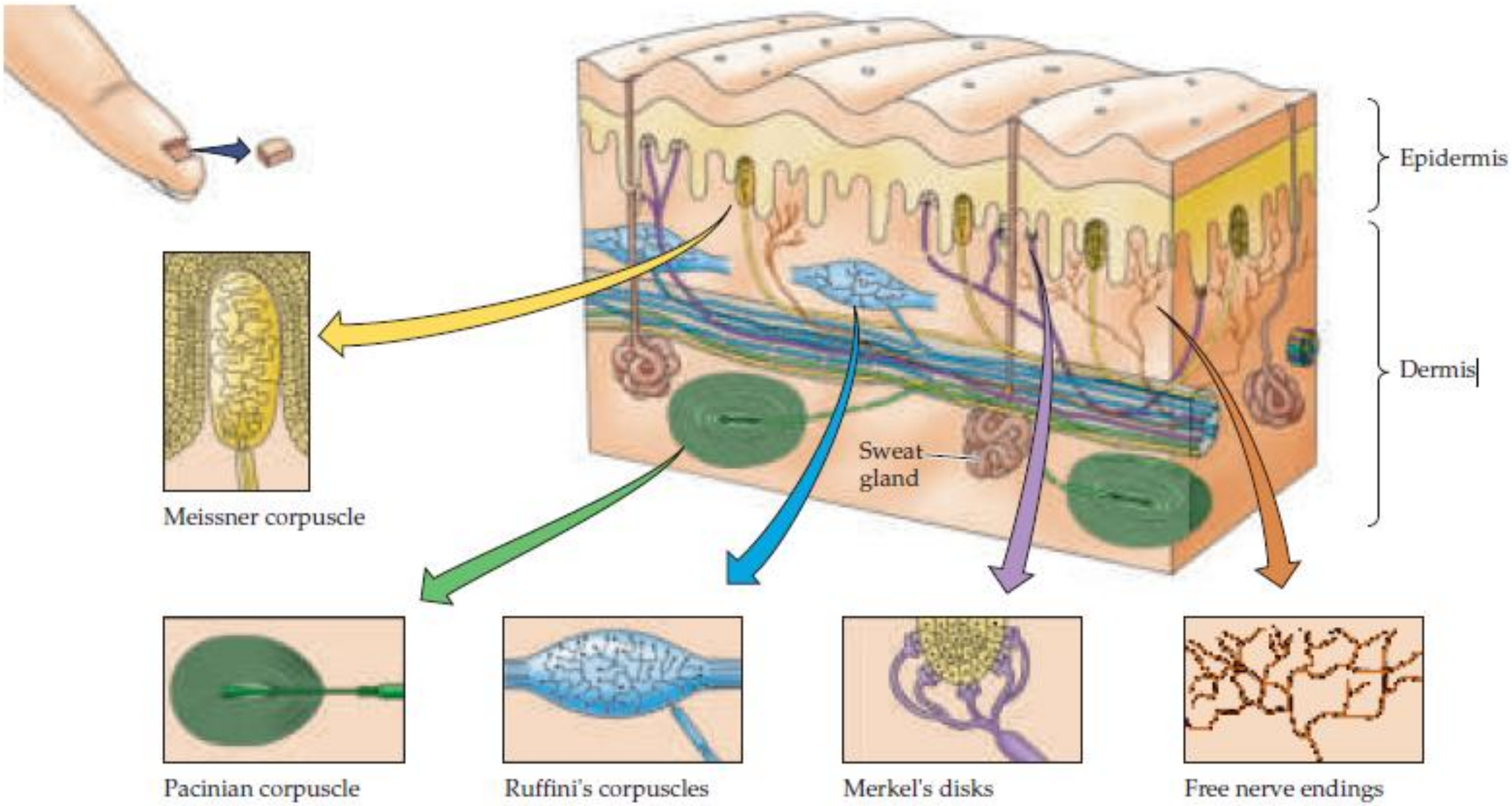
Recapitulation L10

- The stretch reflex response relies on one of the simples complete functional circuits.
- We have put together the necessary elements and looked at their function.
- Muscle spindle, stretch receptor, afferent axon, synapse, motoneuron, efferent axon, neuromuscular endplate, muscle…

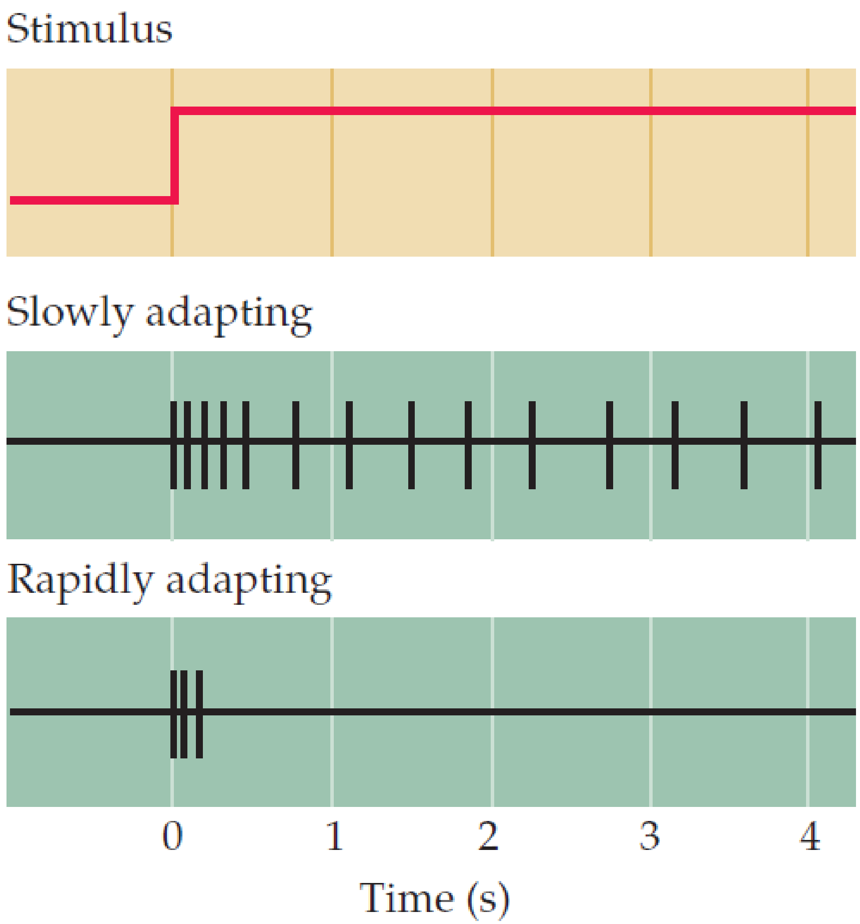
Mechanical stimuli and temperature

THE SOMATOSENSORY SYSTEM

The Sensors

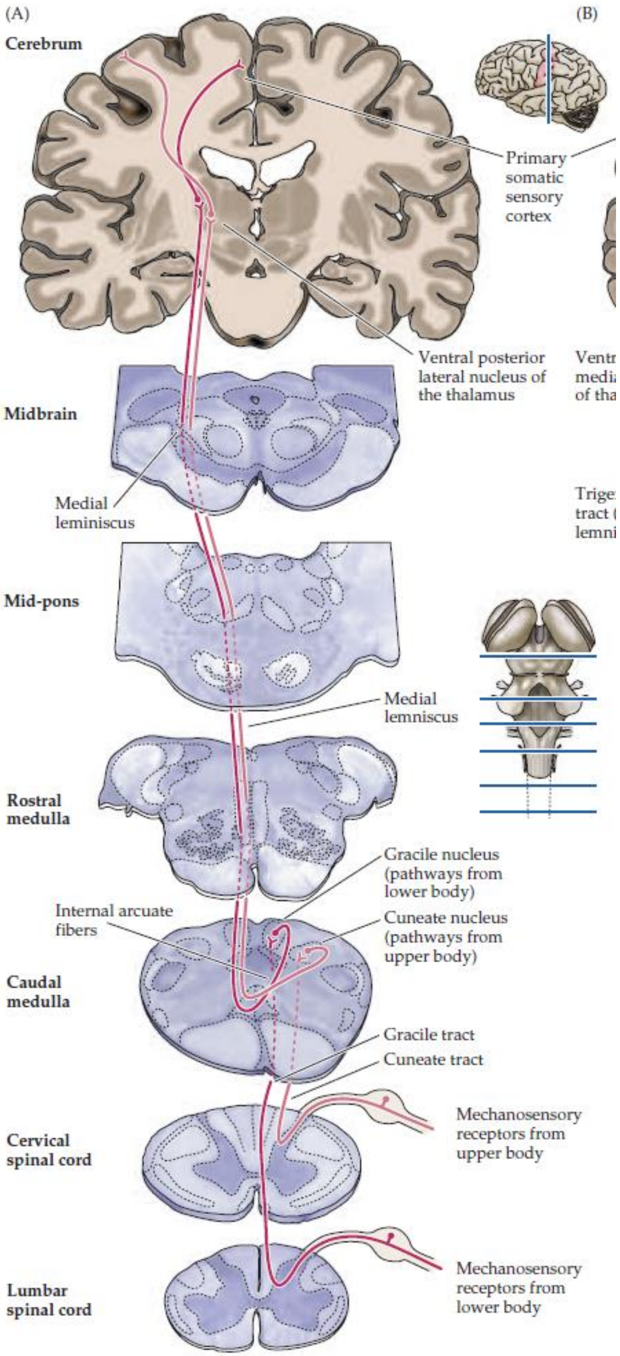

Epidermis
Dermis
Sweat gland
Meissner corpuscle
Pacinian corpuscle
Ruffini's corpuscles
Merkel's disks
Free nerve endings

Transducer Responses



This an example of feature extraction at a very early stage. A change in the stimulus is more important than the constant presence of a stimulus.

Somatosensory Pathways



Information from the periphery (sensor) reaches the cortex in three synaptic steps.

This is the case for all senses except smell.

The information from all senses (except smell) passes through thalamic nuclei and is relayed there.

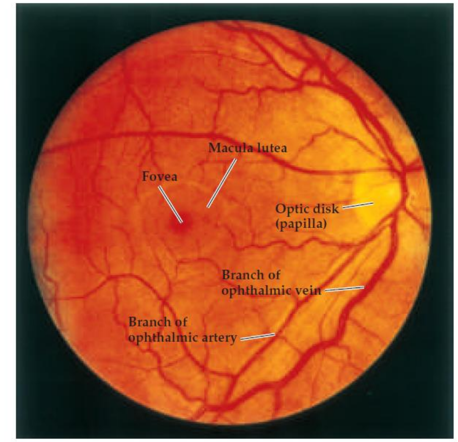
The thalamus is considered to be the gating structure for the flow of information to the cortex.

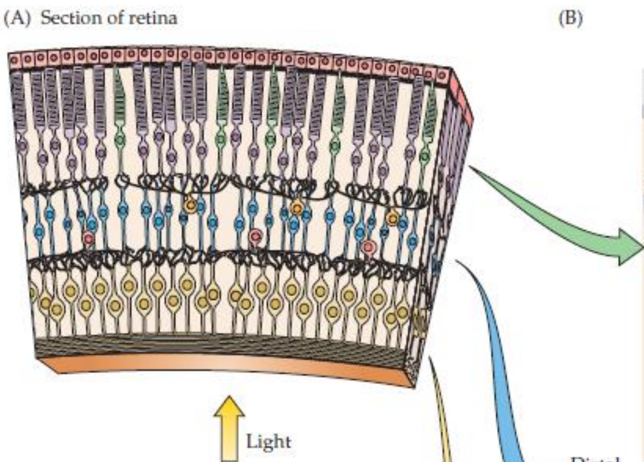
It receives many more top-down connections from the cortex than bottom-up connections from the periphery.

Light and dark

THE VISUAL SYSTEM

The Sensors





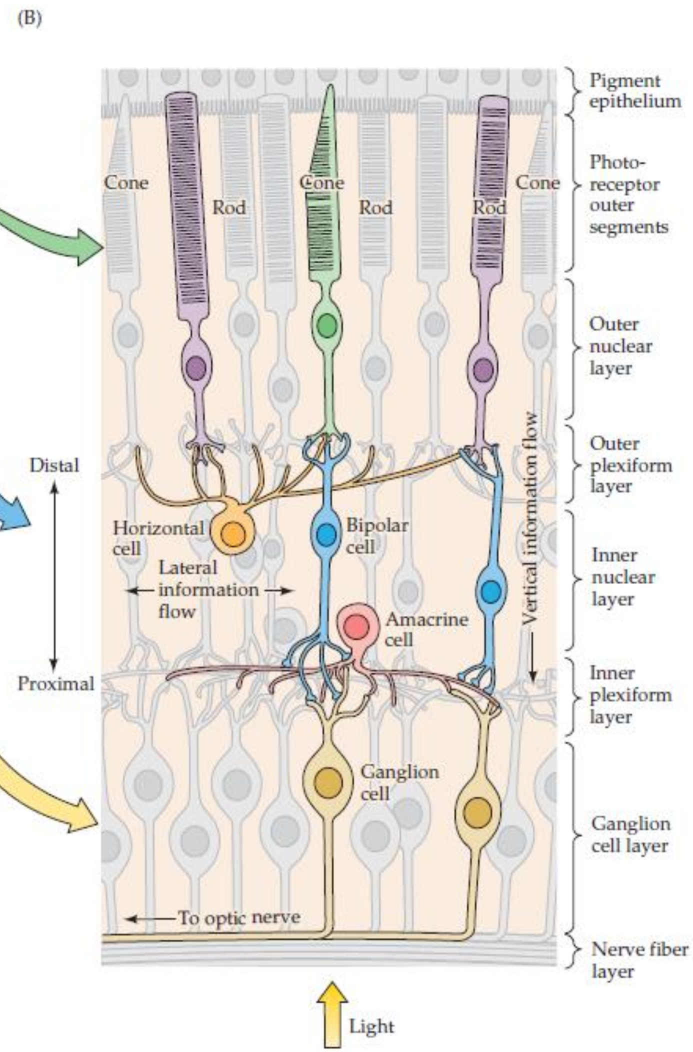
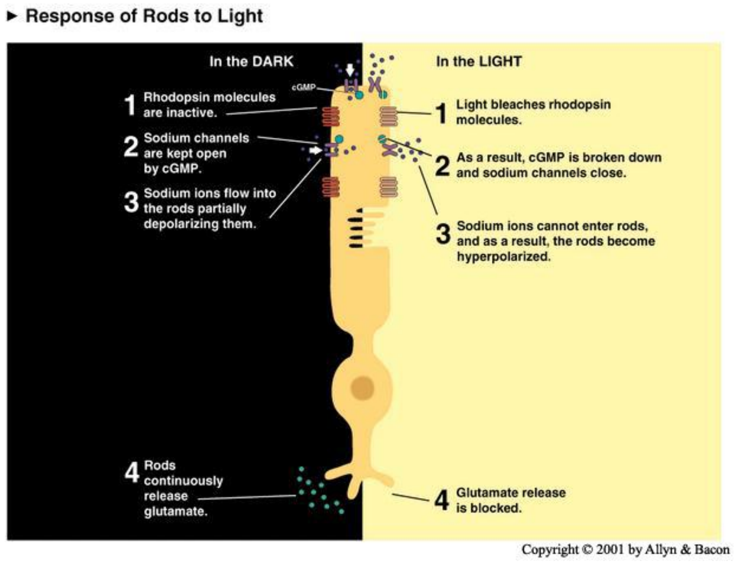


Figure 10.4 Structure of the retina. (A) Section of the retina showing overall arrangement of retinal layers. (B) Diagram of the basic circuitry of the retina. A three-neuron chain—photoreceptor, bipolar cell, and ganglion cell—provides the most direct route for transmitting visual information to the brain. Horizontal cells and amacrine cells mediate lateral interactions in the outer and inner plexiform layers, respectively. The terms *inner* and *outer* designate relative distances from the center of the eye (inner, near the center of the eye; outer, away from the center, or toward the pigment epithelium).

Light travels through the inner layers of the retina to reach the photoreceptors.

The retina is the only part of the central nervous system that is directly visible from the outside

Visual System Transducer



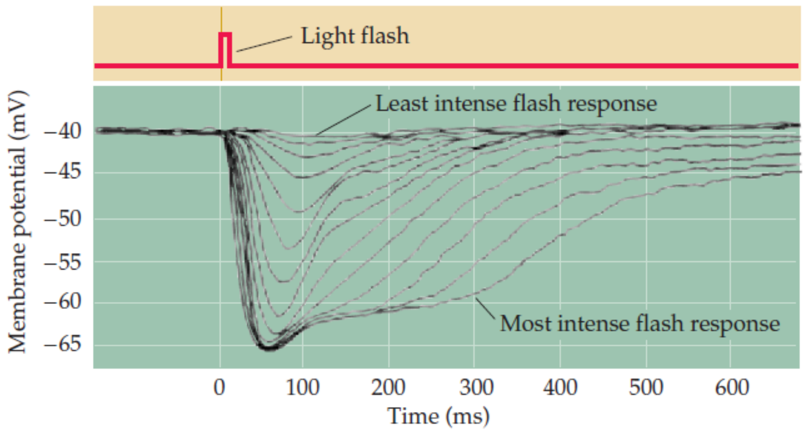
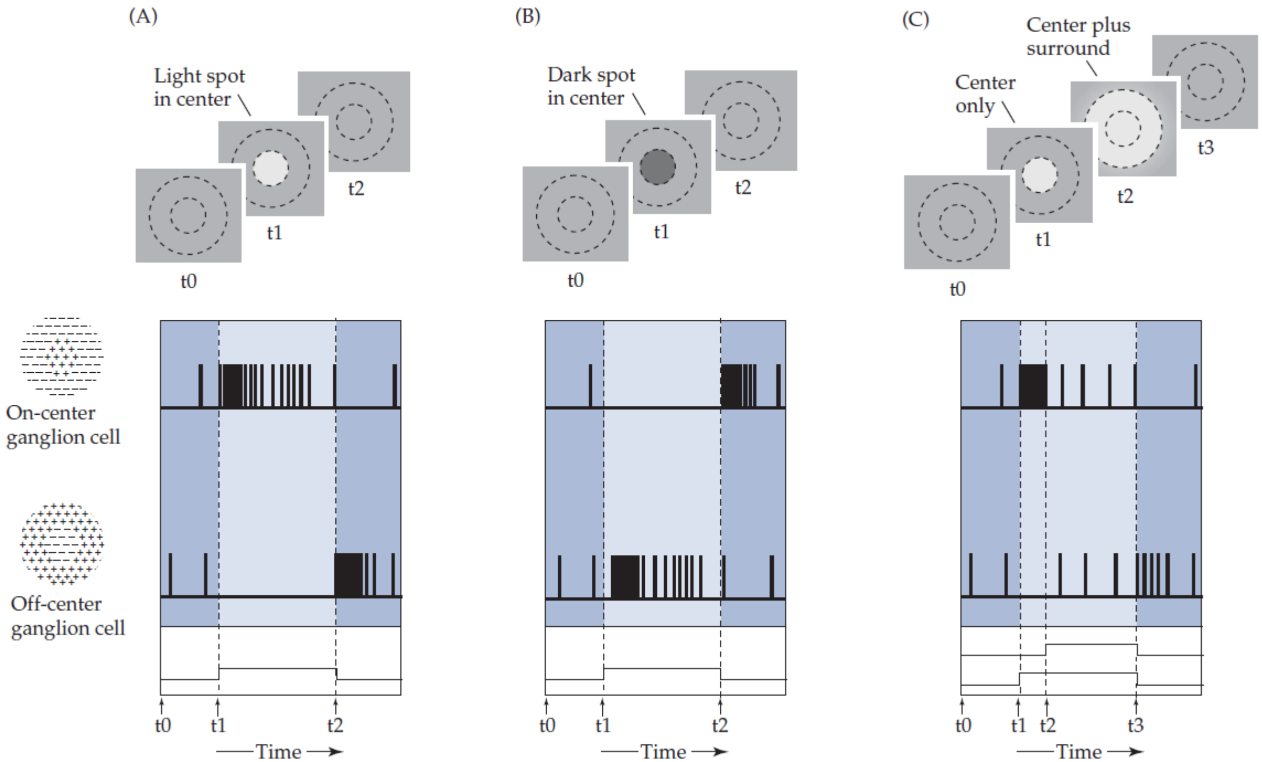


Figure 10.5 An intracellular recording from a single cone stimulated with different amounts of light (the cone has been taken from the turtle retina, which accounts for the relatively long time course of the response). Each trace represents the response to a brief flash that was varied in intensity. At the highest light levels, the response amplitude saturates (at about –65 mV). The hyperpolarizing response is characteristic of vertebrate photoreceptors; interestingly, some invertebrate photoreceptors depolarize in response to light. (After Schnapf and Baylor, 1987.)

Feature Extraction



Visual processing starts already in the retina.
Ganglion cells can have on-center or off-center receptive fields.

Central Vision Pathways

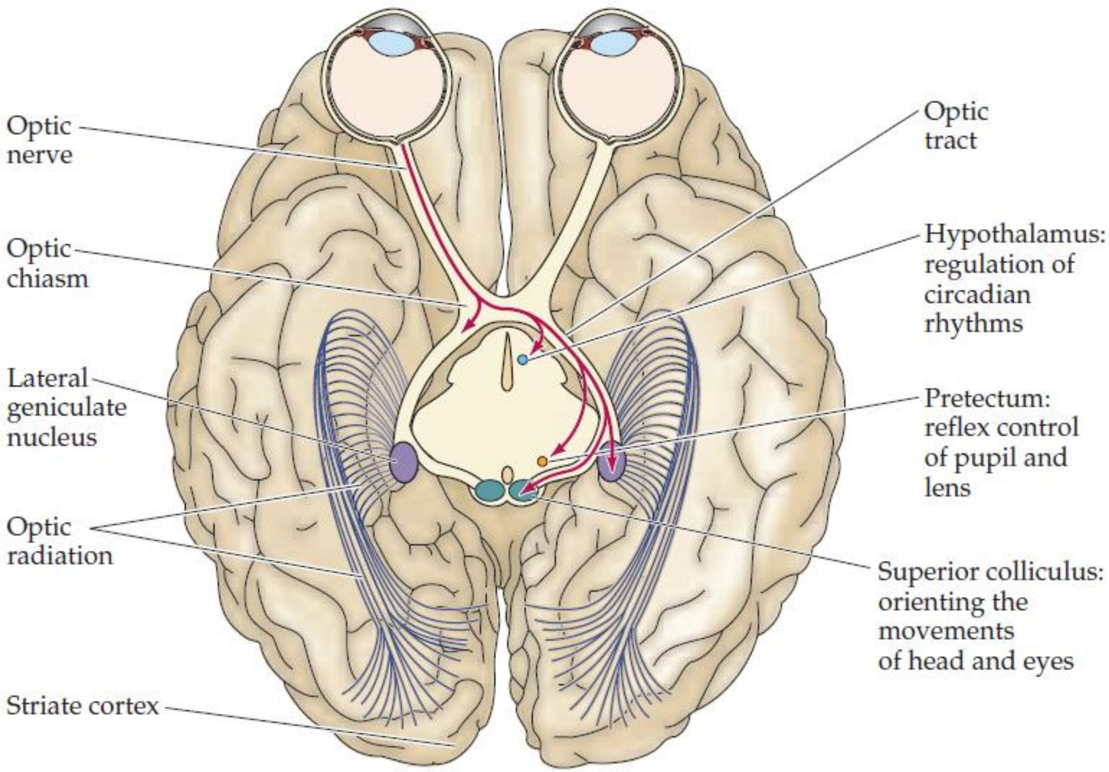


Figure 11.2 Central projections of retinal ganglion cells. Ganglion cell axons terminate in the lateral geniculate nucleus of the thalamus, the superior colliculus, the pretectum, and the hypothalamus. For clarity, only the crossing axons of the right eye are shown (view is looking up at the inferior surface of the brain).

sylvius

Central Responses

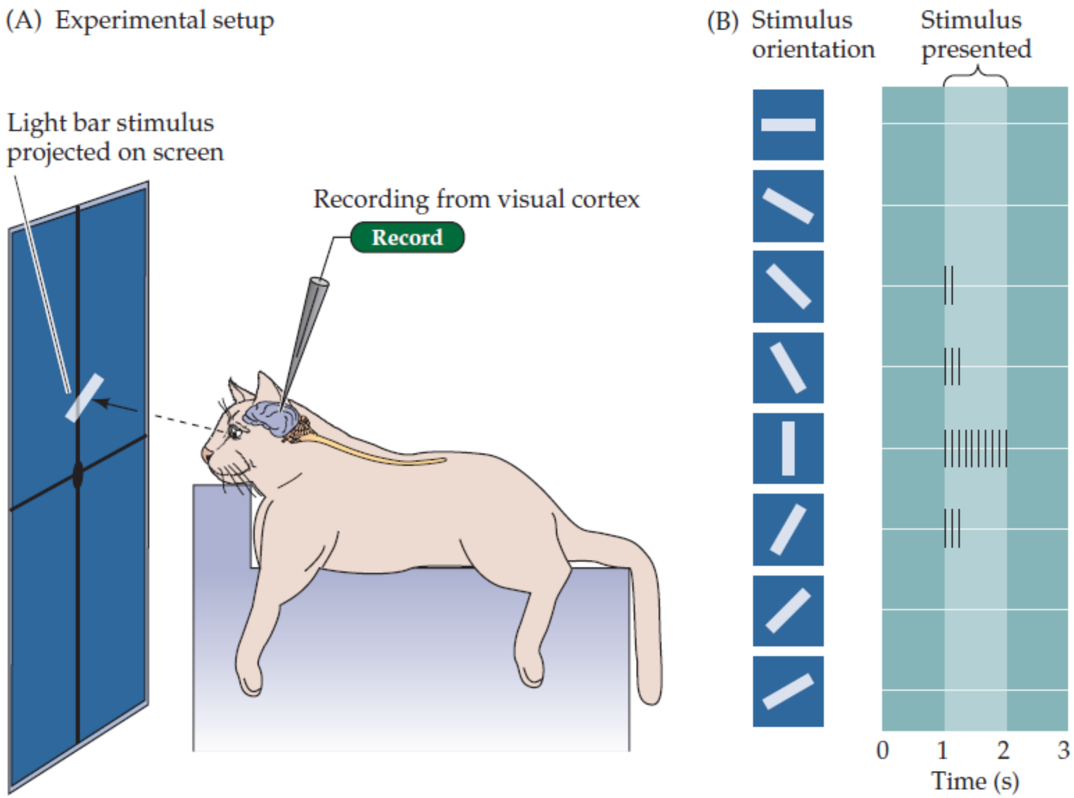
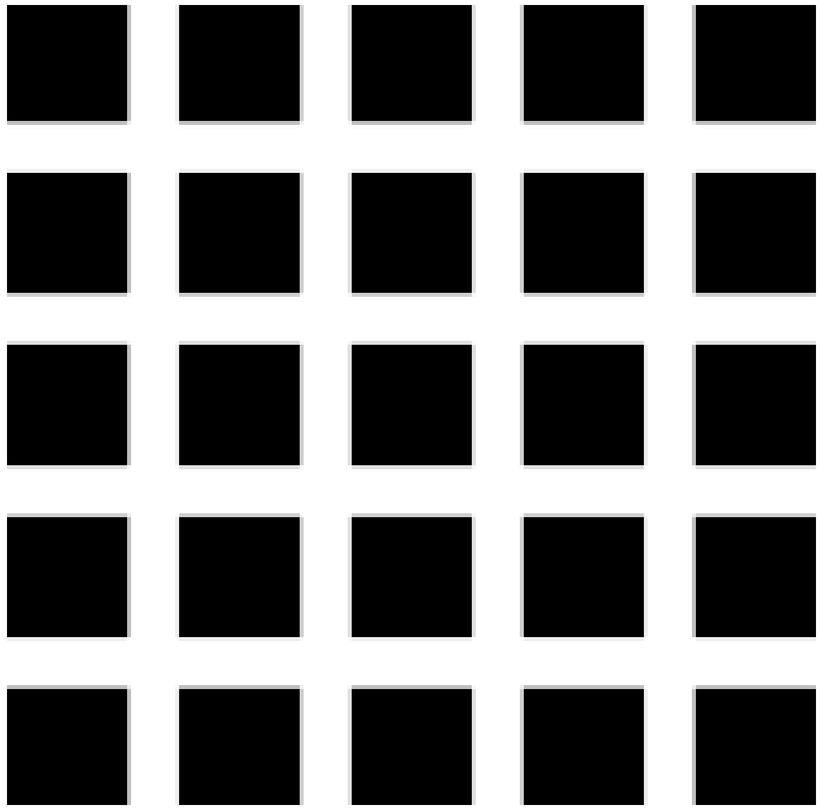


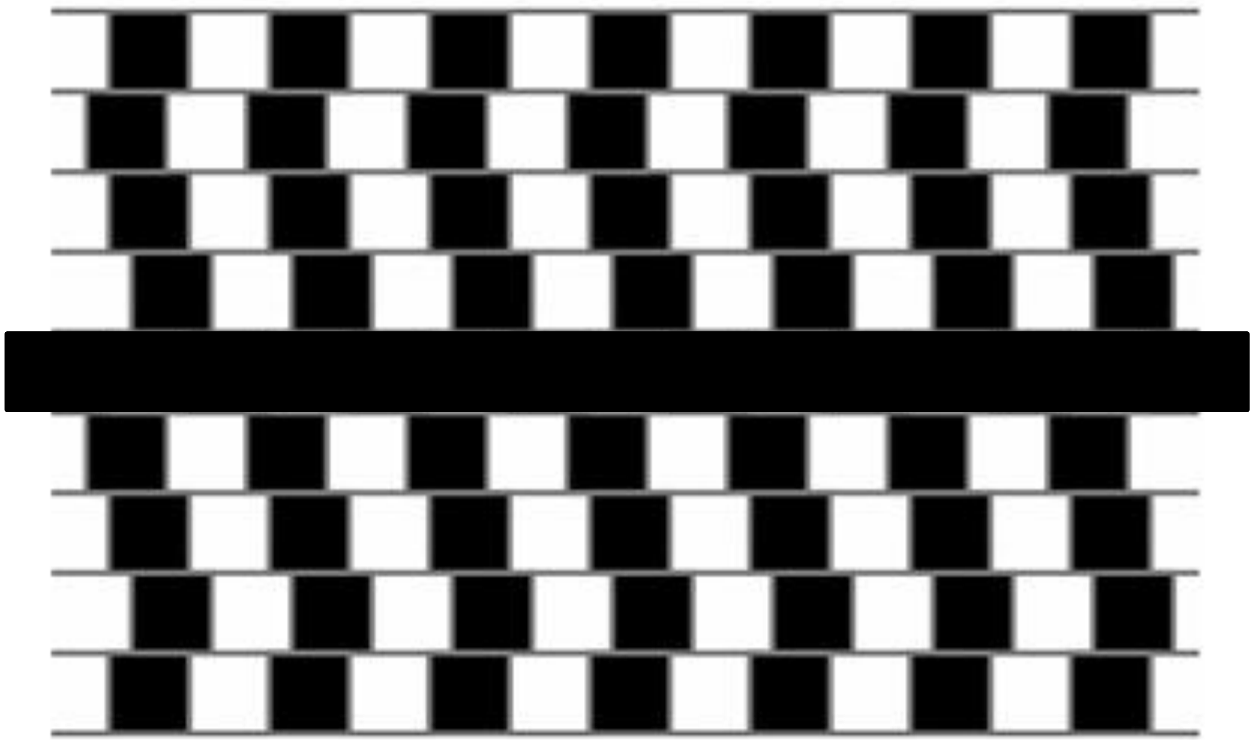
Figure 11.9 Neurons in the primary visual cortex respond selectively to oriented edges. (A) An anesthetized animal is fitted with contact lenses to focus the eyes on a screen, where images can be projected; an extracellular electrode records the neuronal responses. (B) Neurons in the primary visual cortex typically respond vigorously to a bar of light oriented at a particular angle and weakly—or not at all—to other orientations.

The feature extraction continues....

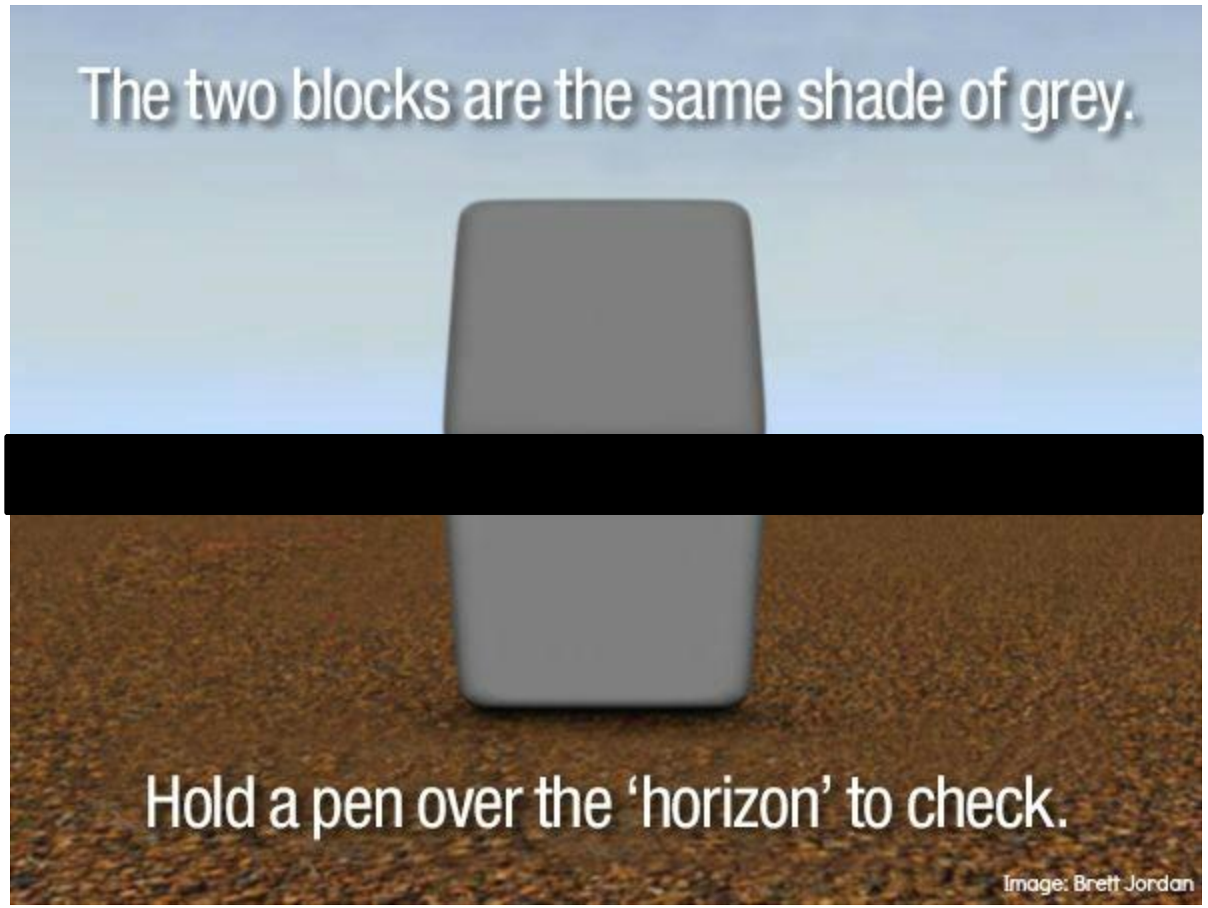
Hermann Grid Illusion



Café Wall Illusion (M. Gregory)



Context is Everything..



Detecting volatile chemicals

SMELL

General Organization

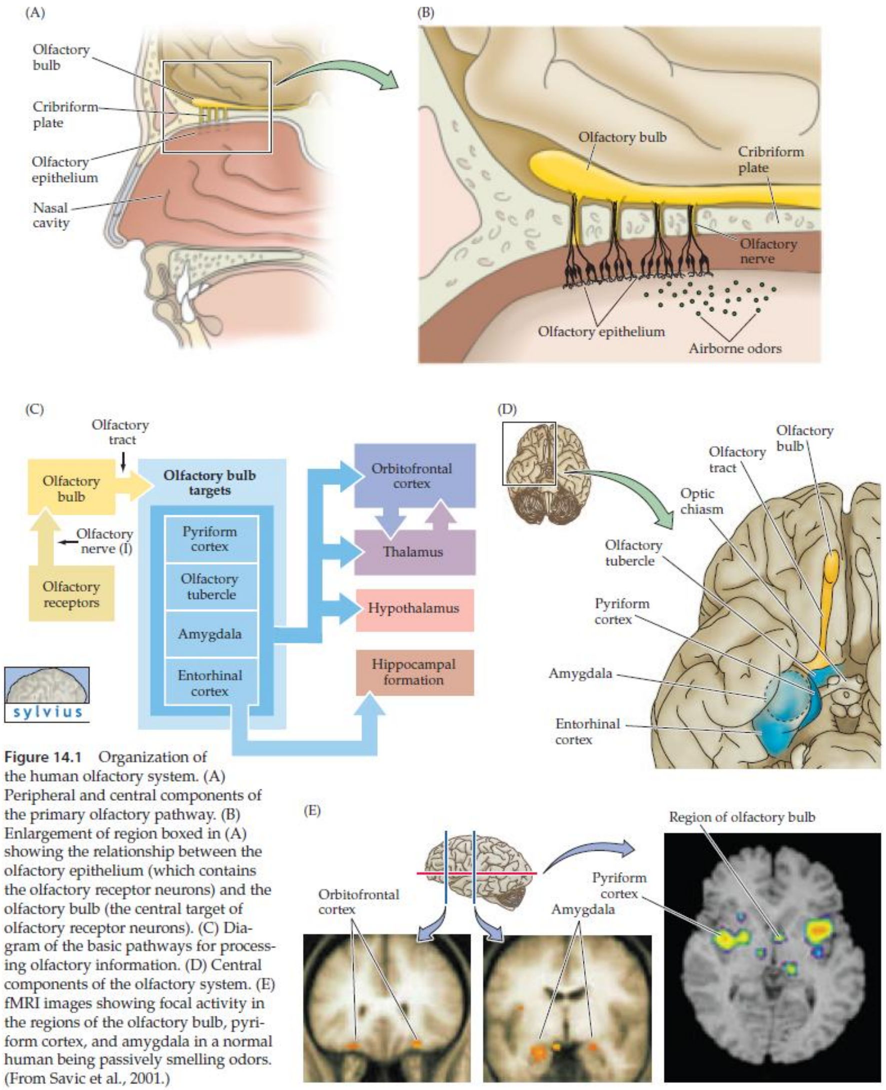
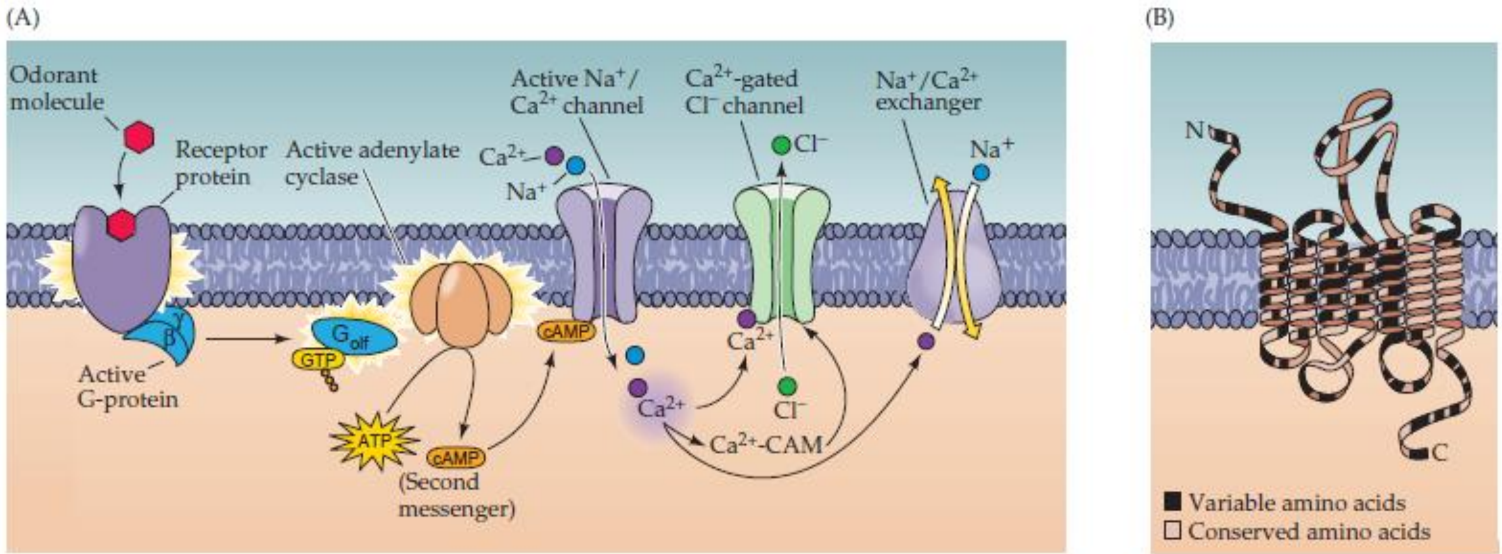


Figure 14.1 Organization of the human olfactory system. (A) Peripheral and central components of the primary olfactory pathway. (B) Enlargement of region boxed in (A) showing the relationship between the olfactory epithelium (which contains the olfactory receptor neurons) and the olfactory bulb (the central target of olfactory receptor neurons). (C) Diagram of the basic pathways for processing olfactory information. (D) Central components of the olfactory system. (E) fMRI images showing focal activity in the regions of the olfactory bulb, pyriform cortex, and amygdala in a normal human being passively smelling odors. (From Savic et al., 2001.)

The sensory neurons in the olfactory epithelium are constantly regenerated – thus maintaining function in a hostile environment.

Signal Transduction



A very large family of G-protein coupled receptors.... > 900 members in humans..

Odorant Coding