Chapter 50

Sensory and Motor Mechanisms

PowerPoint® Lecture Presentations for

Biology

Eighth Edition

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Key concepts

1. Sensory mechanisms convert various stimuli into neural codes.
2. Motor mechanisms exert action by skeletons and muscles.

Fig. 50-1

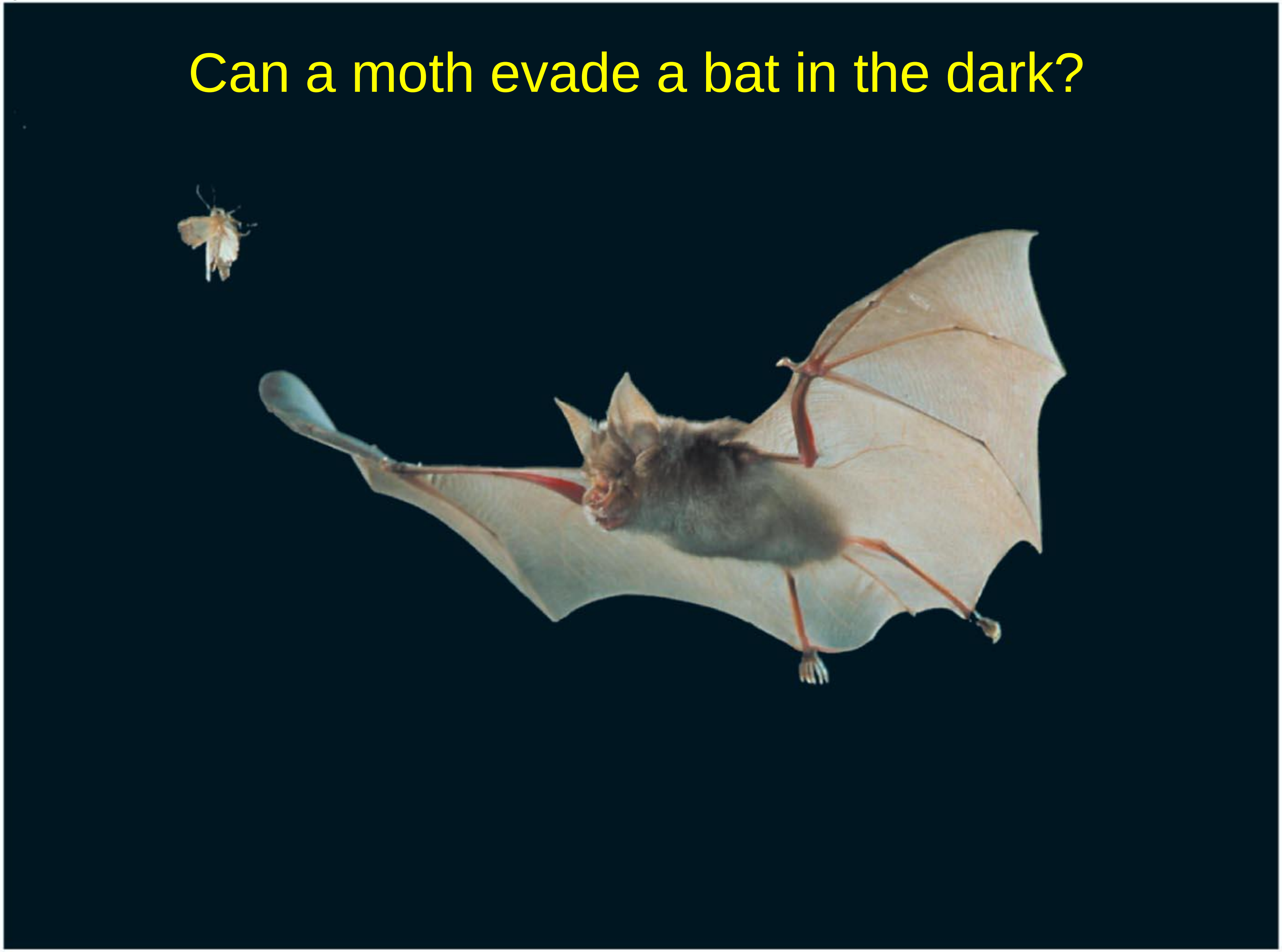
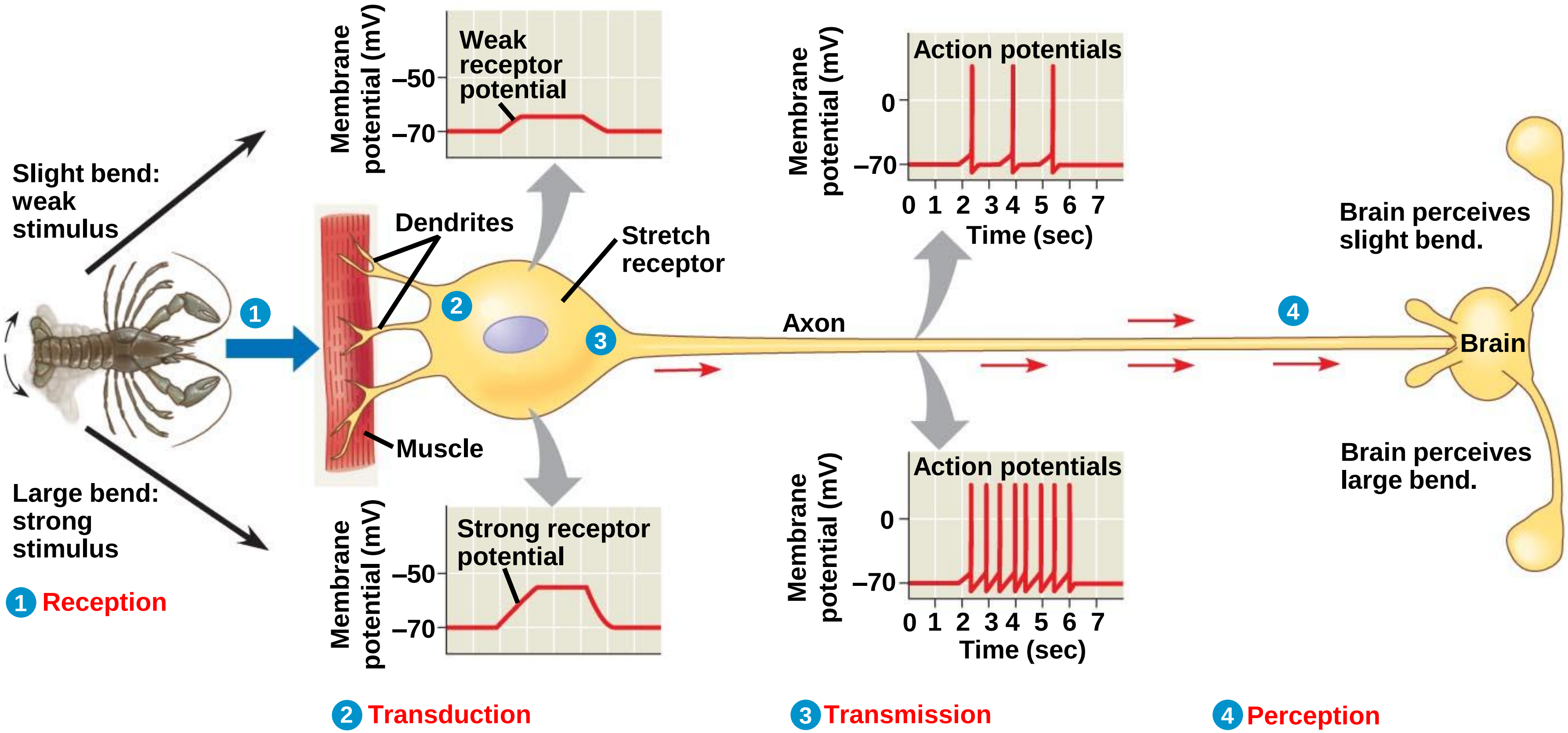
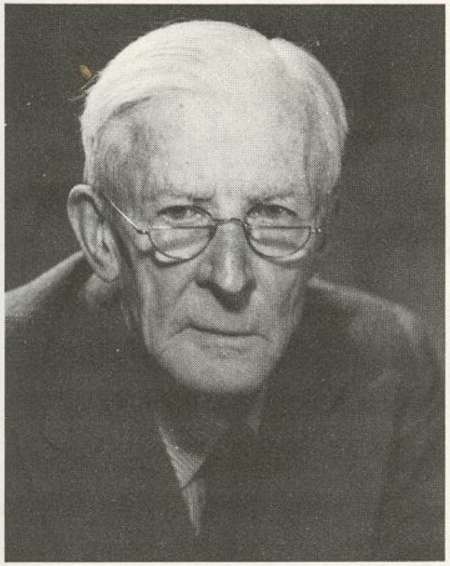


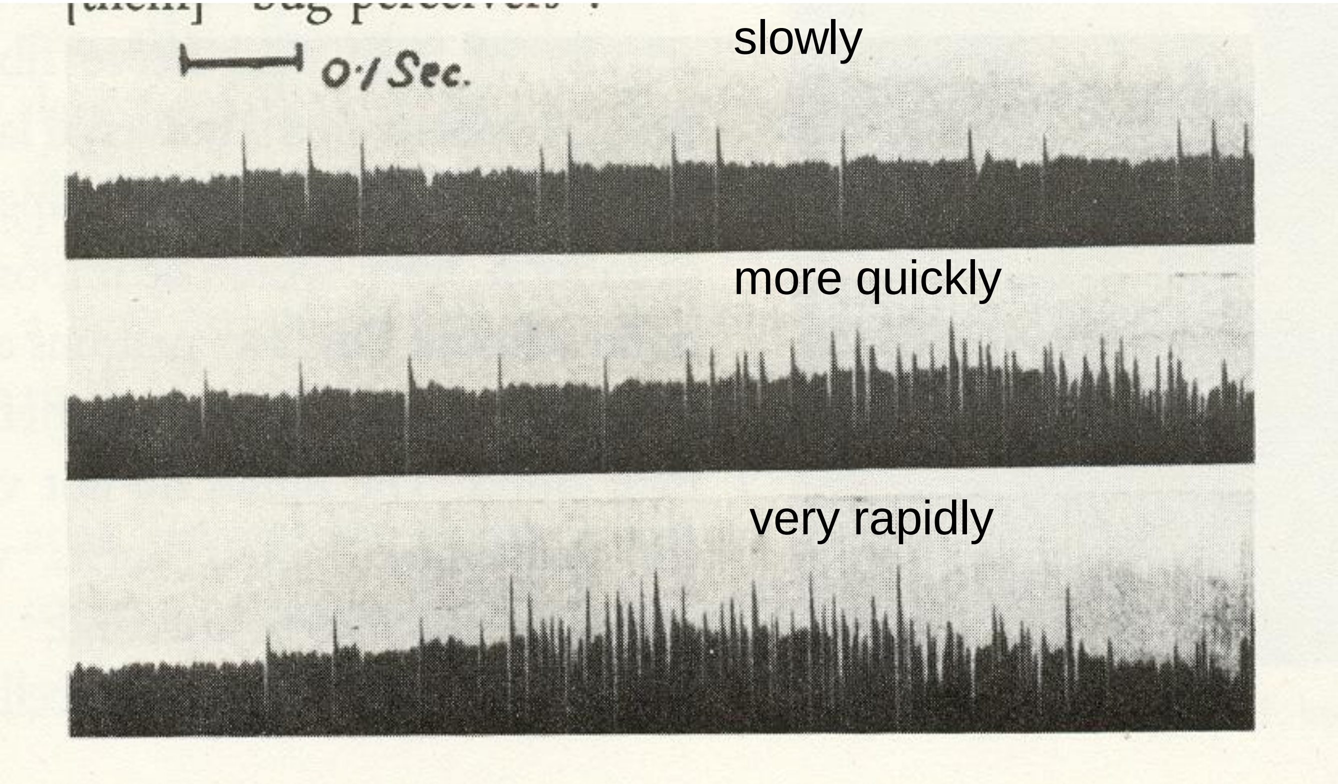
Fig. 50-2

Response of a crayfish stretch receptor to bending





Lord Adrian of Cambridge.



Some of Adrian's first recordings from a very small number of nerve fibers in the sensory nerves of cat's toe (1926).

Adrian's Laws: 1. The nerve impulse (action potential) is "all-or-none"

2. The strength of stimulus is coded by the firing frequency

before the measurement of nerve impulse frequency was made. (From Adrian and Zotterman, 1926.)

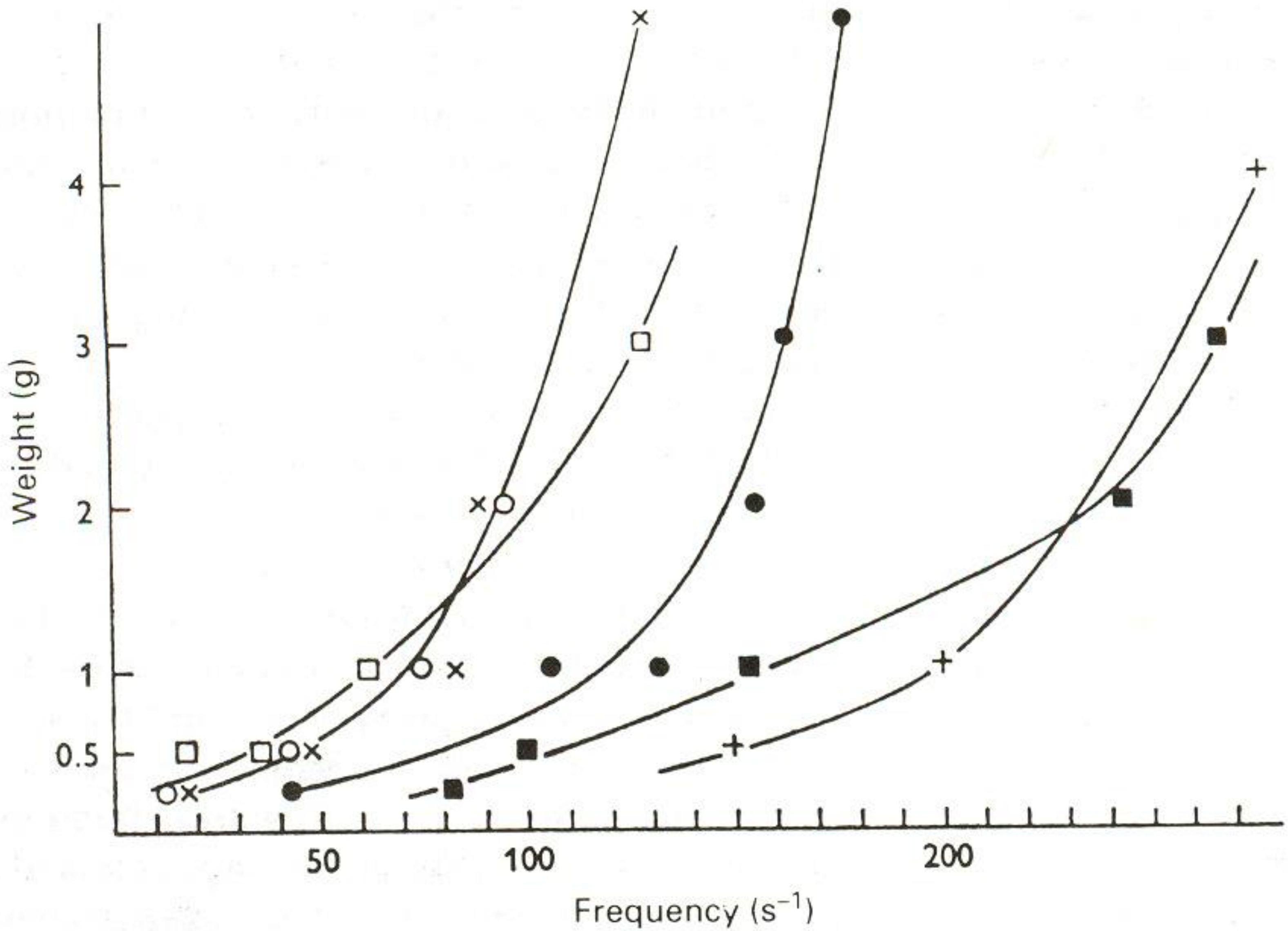
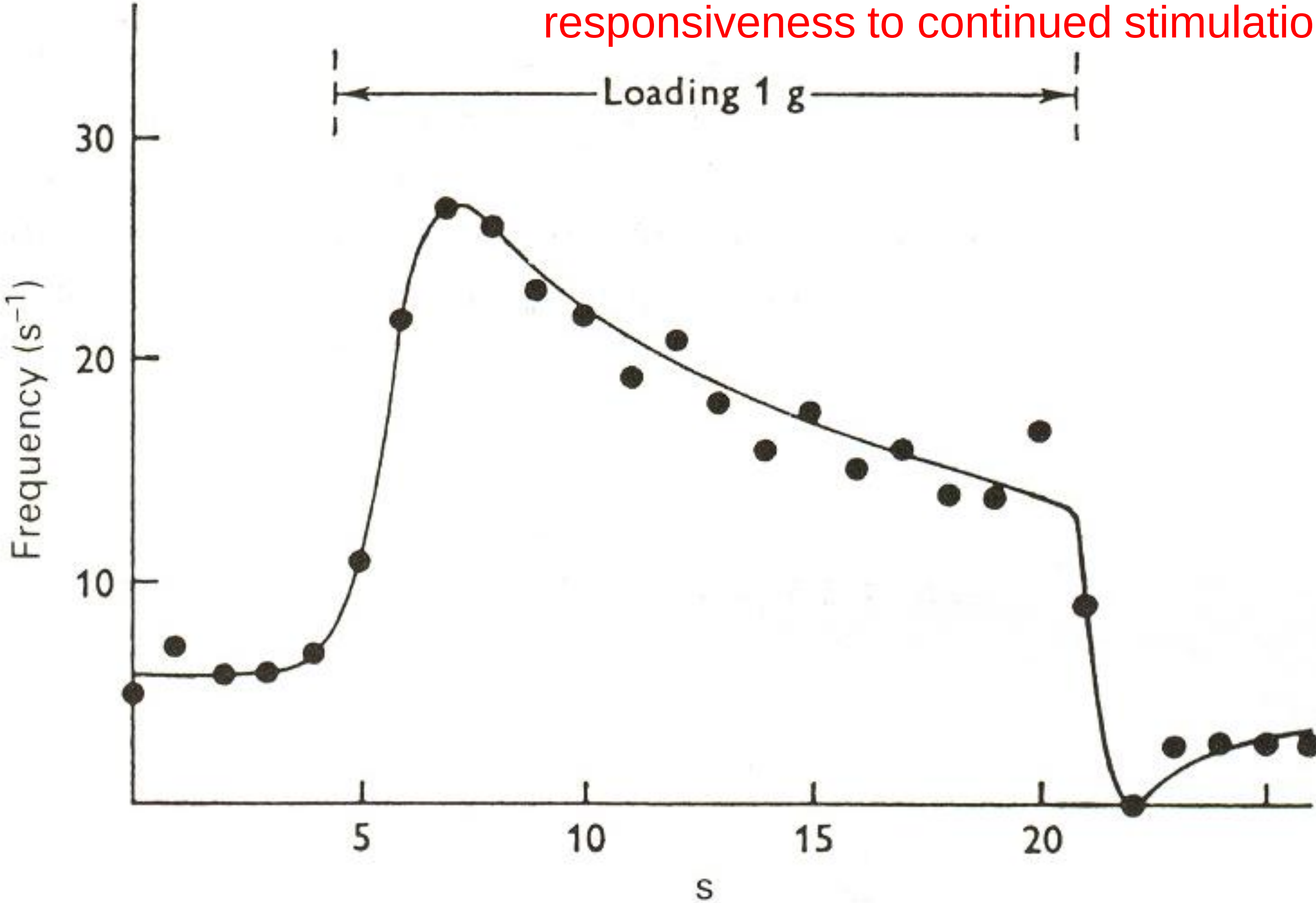


Fig. 16.5. Adaptation in a frog muscle spindle.
(From Adrian and Zotterman, 1926.)

Sensory adaptation is a decrease in responsiveness to continued stimulation



Perception

- **Perceptions** are the brain’s construction of stimuli
- Stimuli from different sensory receptors travel as action potentials along different neural pathways (“**label line**”)

Types of Sensory Receptors

- Based on energy transduced, sensory receptors fall into five categories:
  - Mechanoreceptors
  - Chemoreceptors
  - Electromagnetic receptors
  - Thermoreceptors
  - Pain receptors

Fig. 50-3

Sensory receptors in human skin

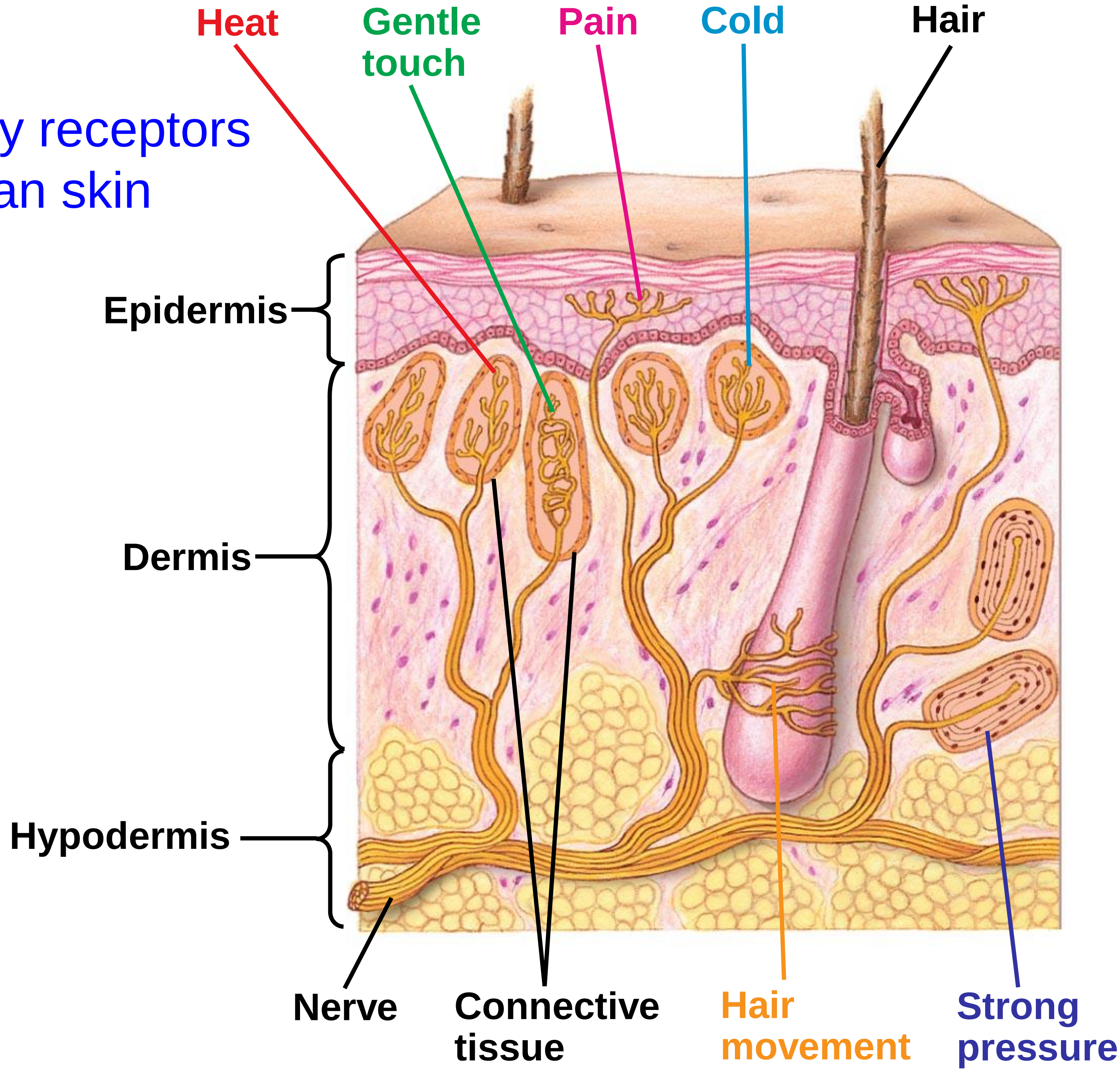


Fig. 50-4

Fig. 50-5

(a) Rattlesnake

(b) Beluga whales

Fig. 50-6

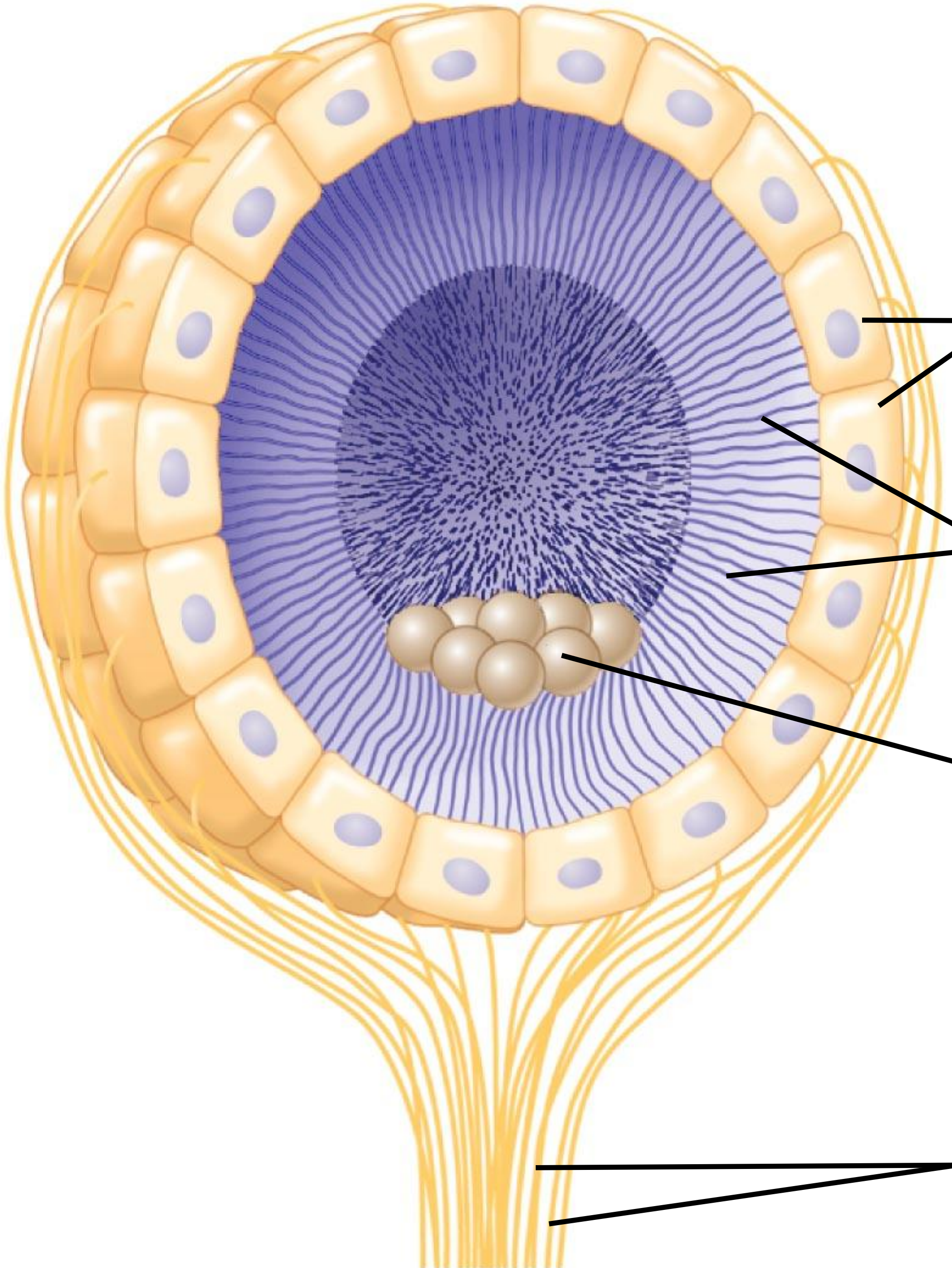


Fig. 50-7

Many arthropods sense sounds with body hairs that vibrate or with localized “ears” consisting of a tympanic membrane and receptor cells

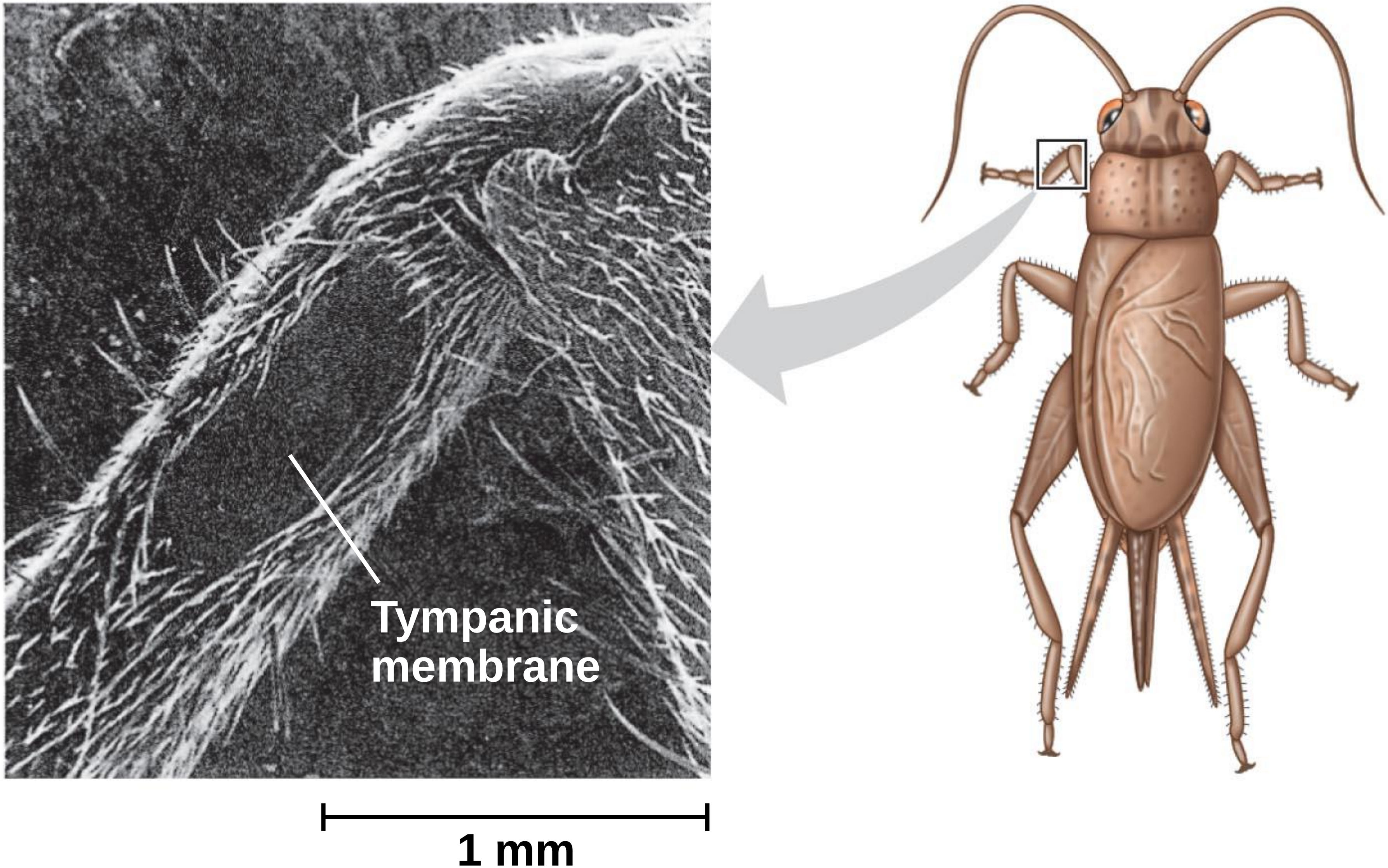
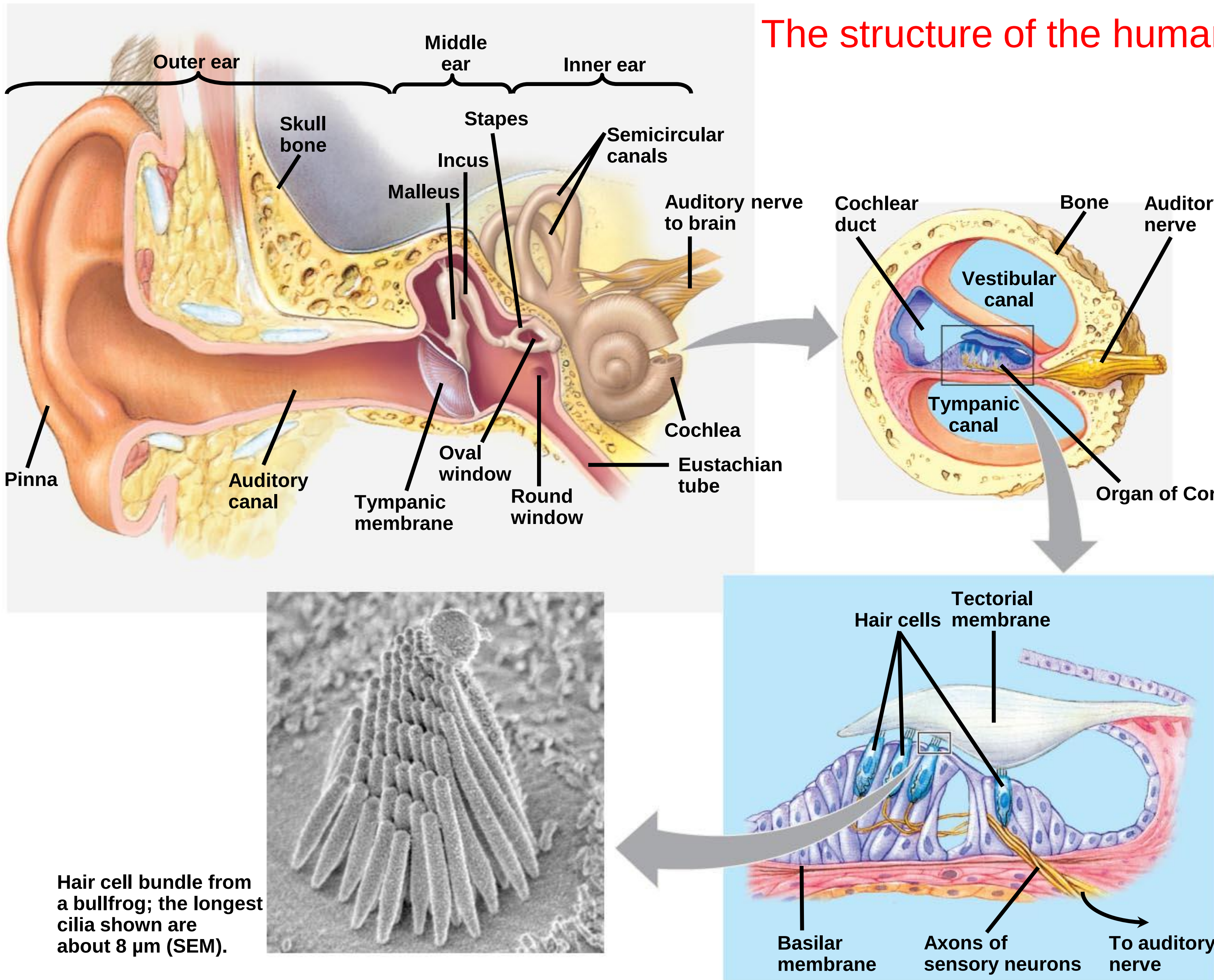


Fig. 50-8

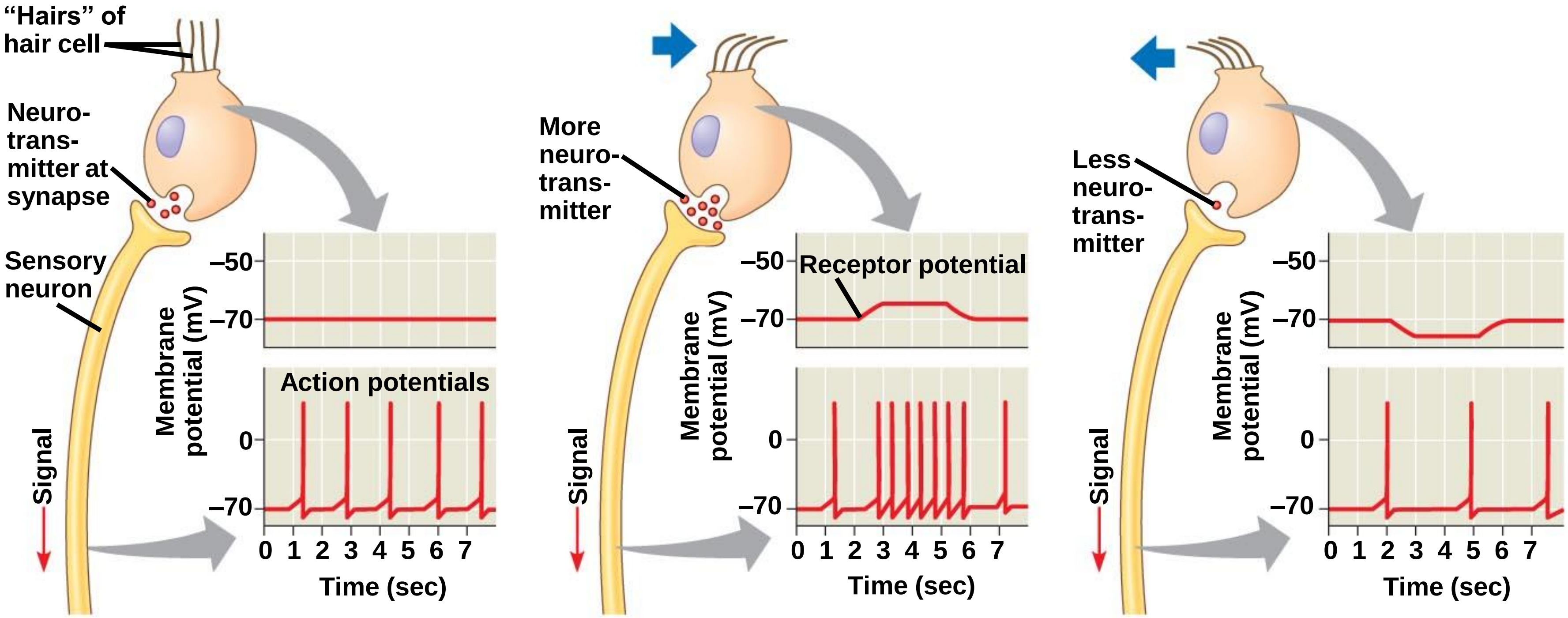
The structure of the human ear



Hair cell bundle from a bullfrog; the longest cilia shown are about 8 µm (SEM).

Fig. 50-9

Sensory reception by hair cells



(a) No bending of hairs (b) Bending of hairs in one direction (c) Bending of hairs in other direction

Fig. 50-10

Transduction in the cochlea

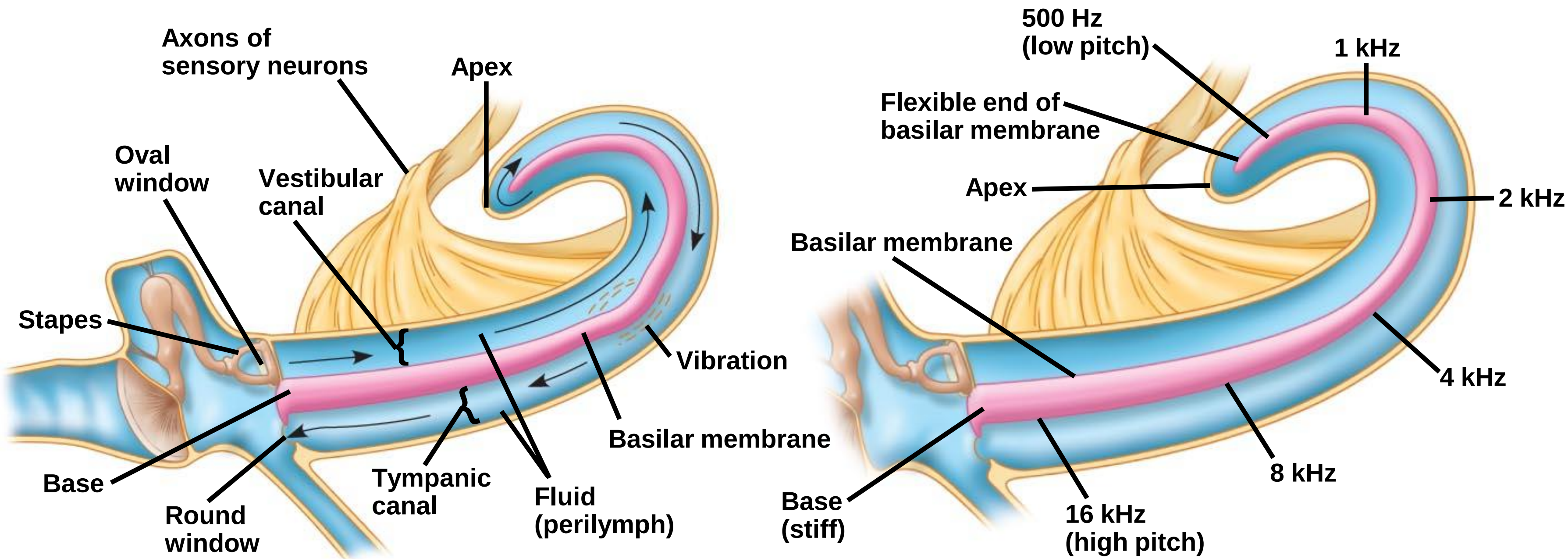
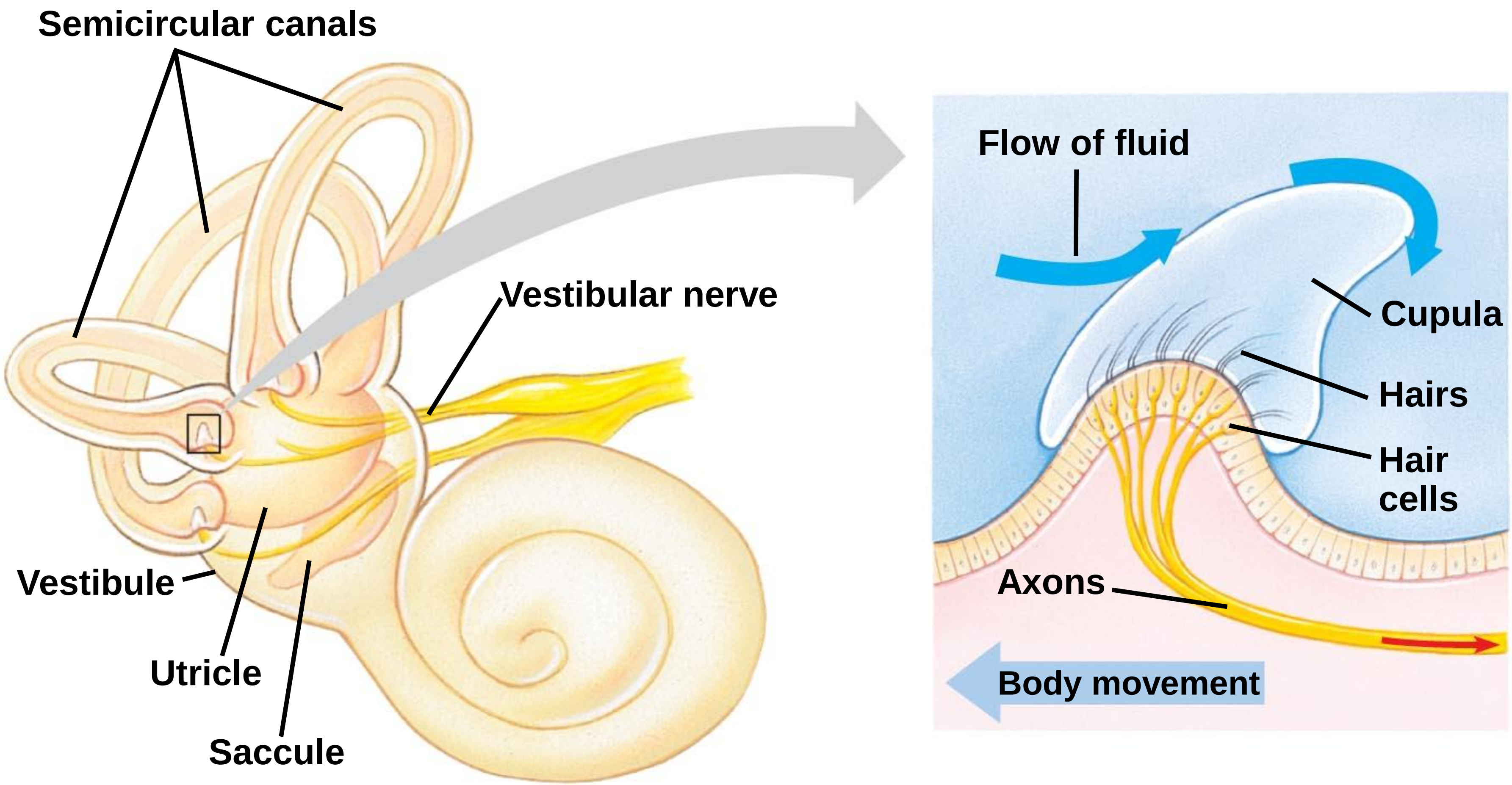


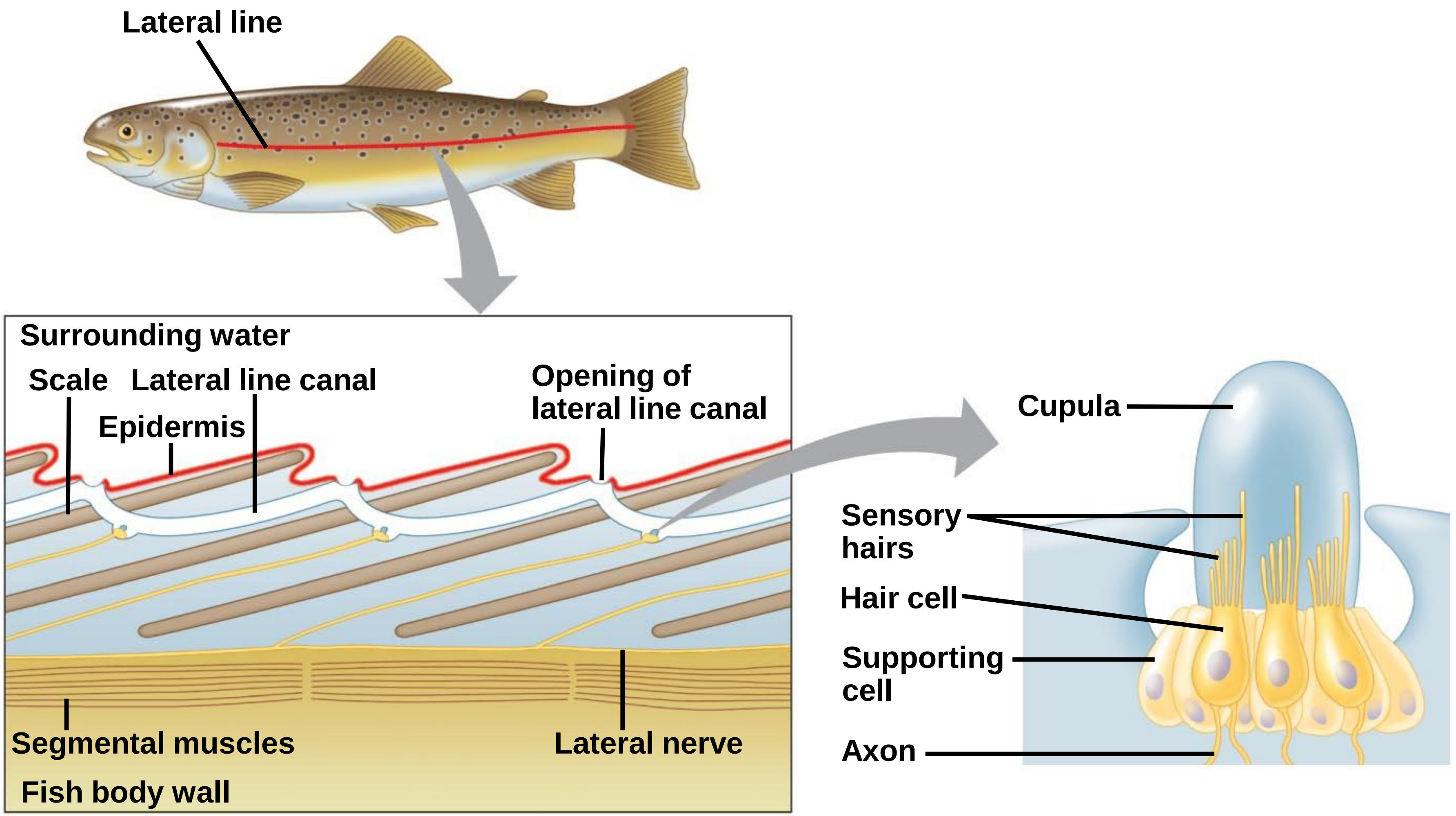
Fig. 50-11



- The **utricle** and **saccule** contain granules called otoliths that allow us to detect gravity and linear movement
- Three semicircular canals contain fluid and allow us to detect angular acceleration such as the turning of the head

Fig. 50-12

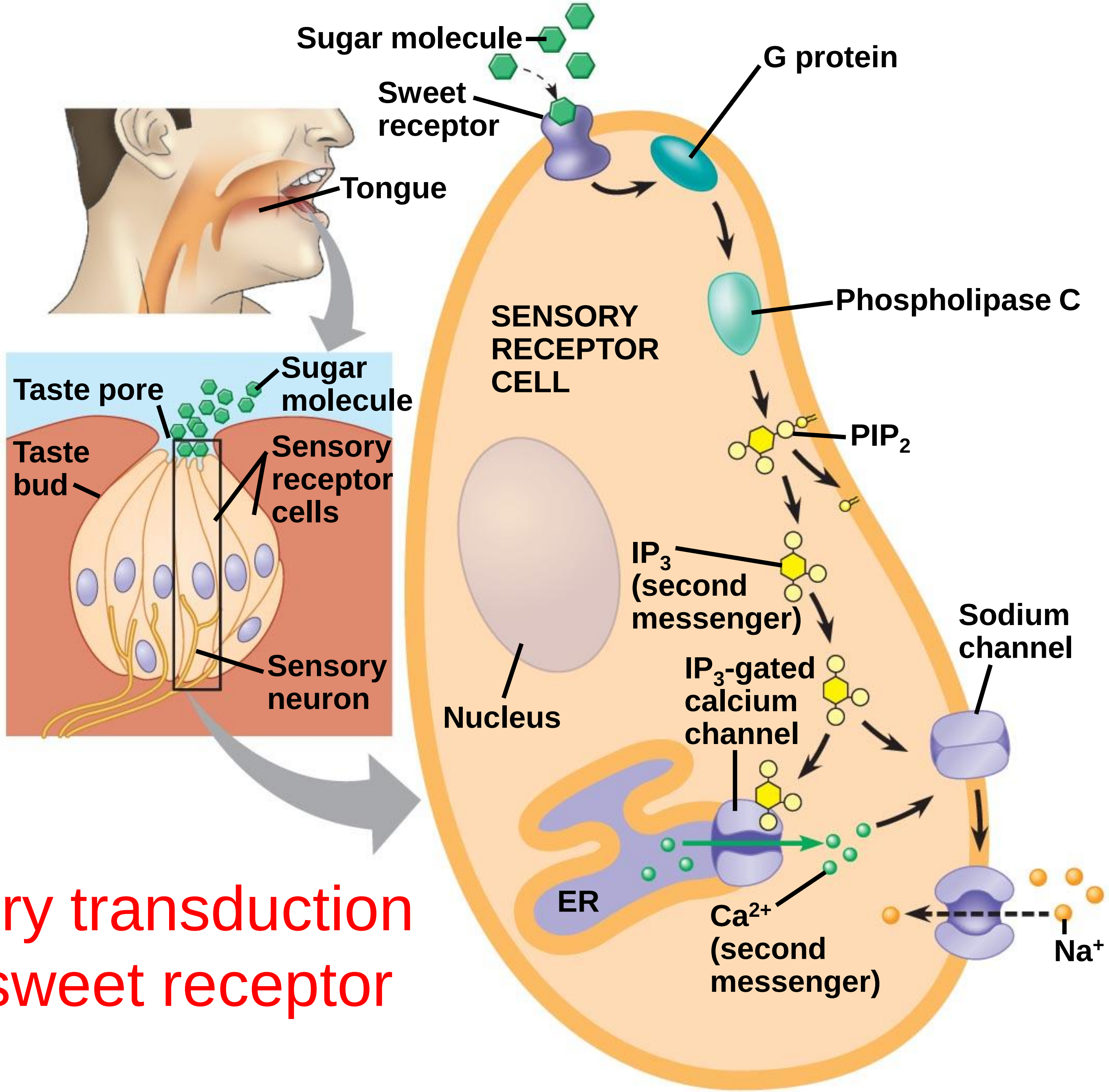
The lateral line system in a fish



Taste in Mammals

- There are five taste perceptions: sweet, sour, salty, bitter, and umami (elicited by glutamate)

Fig. 50-13



Sensory transduction by a sweet receptor

Fig. 50-14

How do mammals detect different tastes?

RESULTS

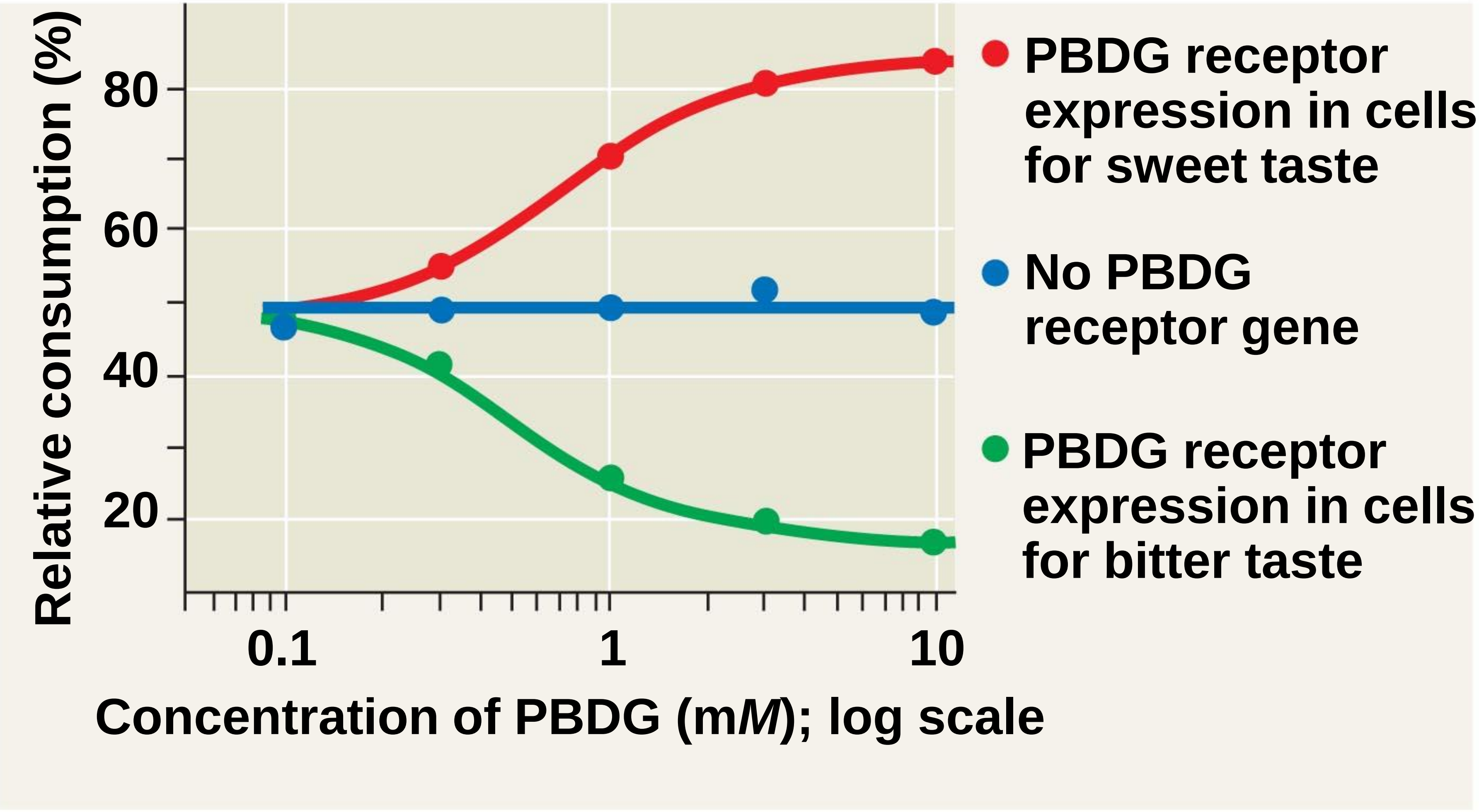


Fig. 50-15

Smell in humans

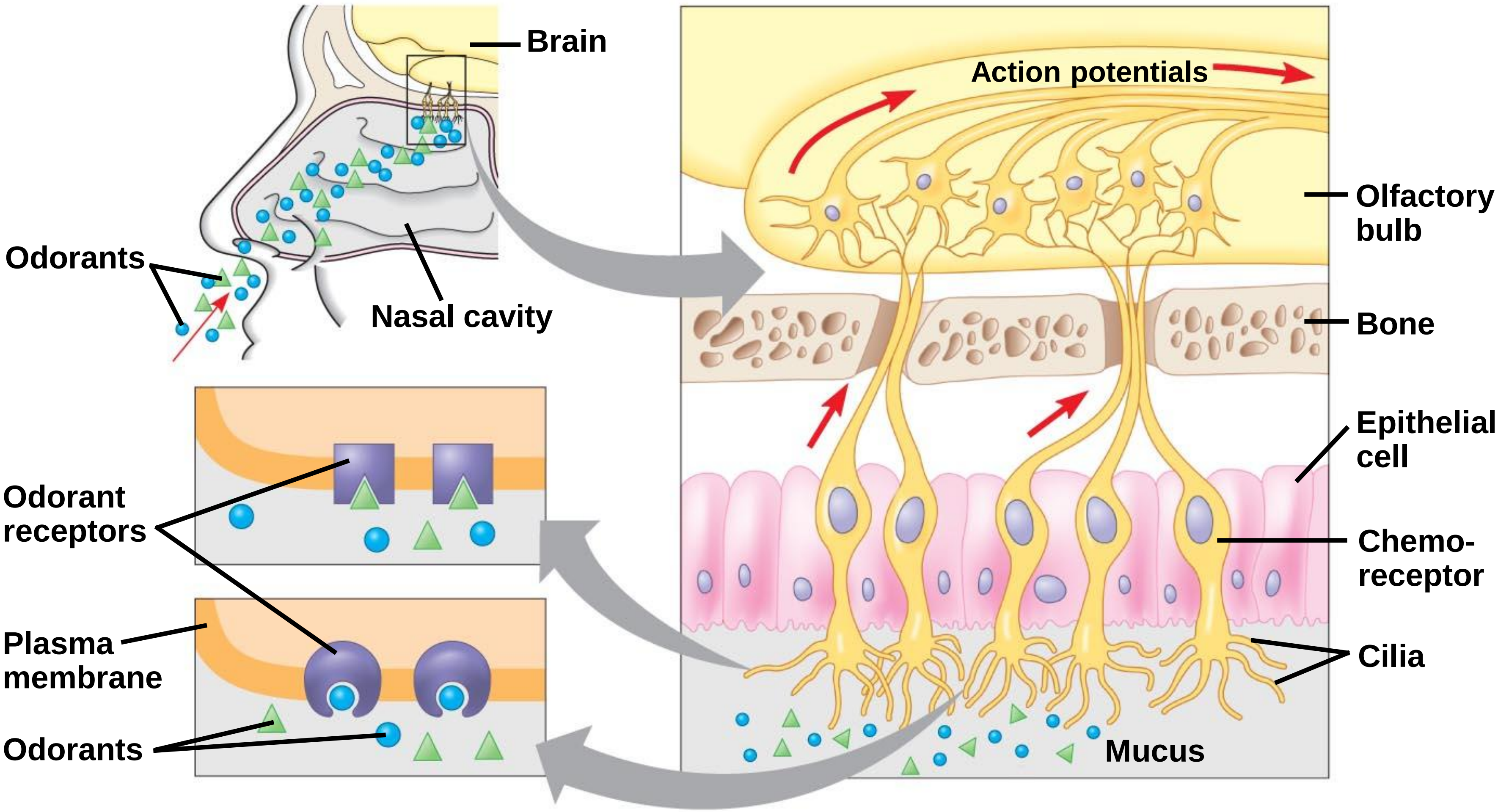
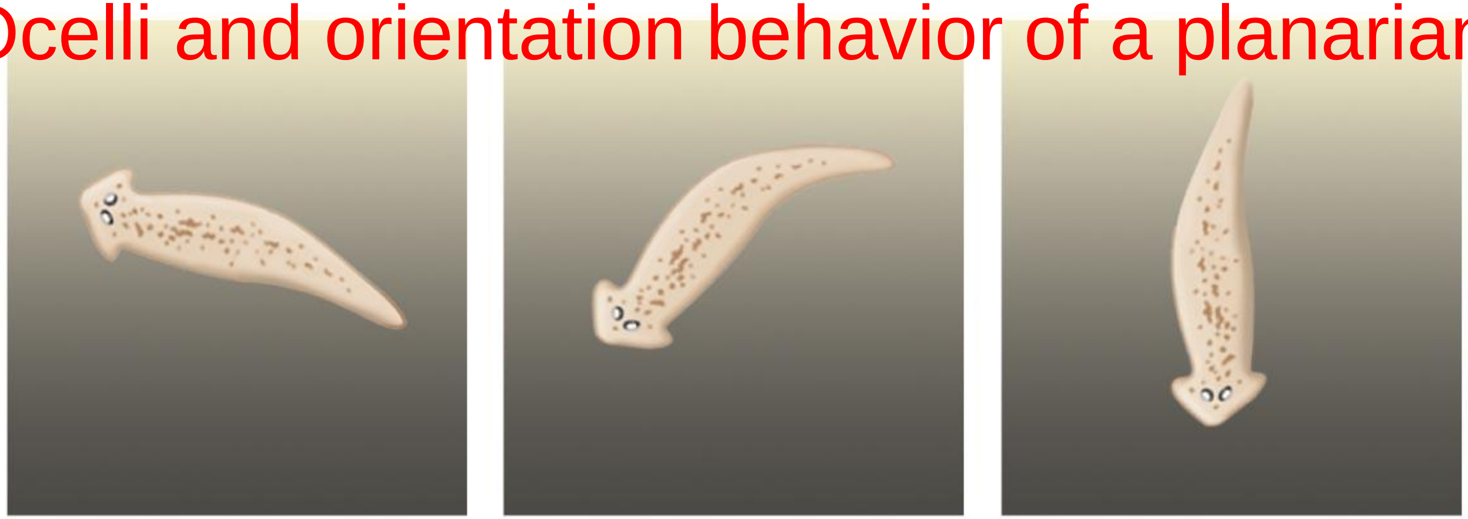


Fig. 50-16

Ocelli and orientation behavior of a planarian



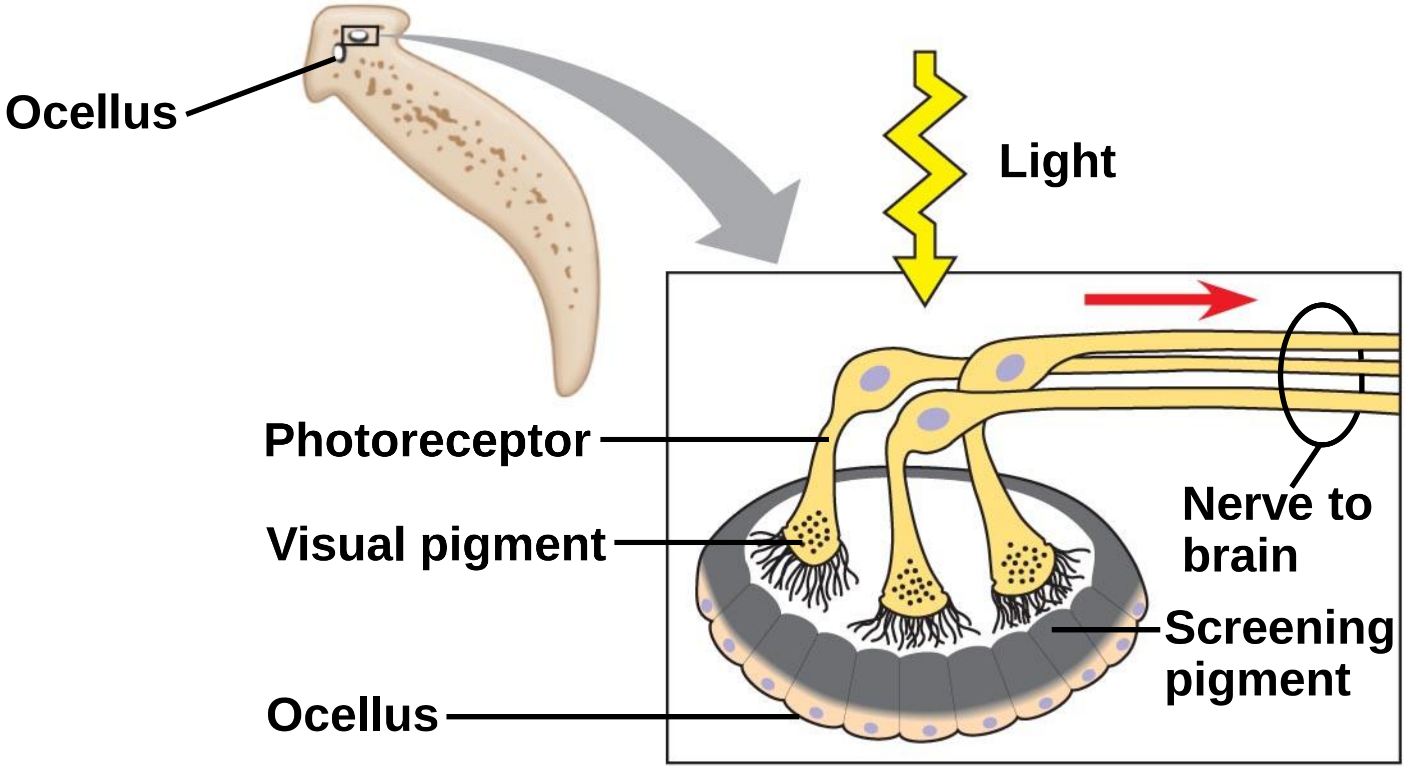
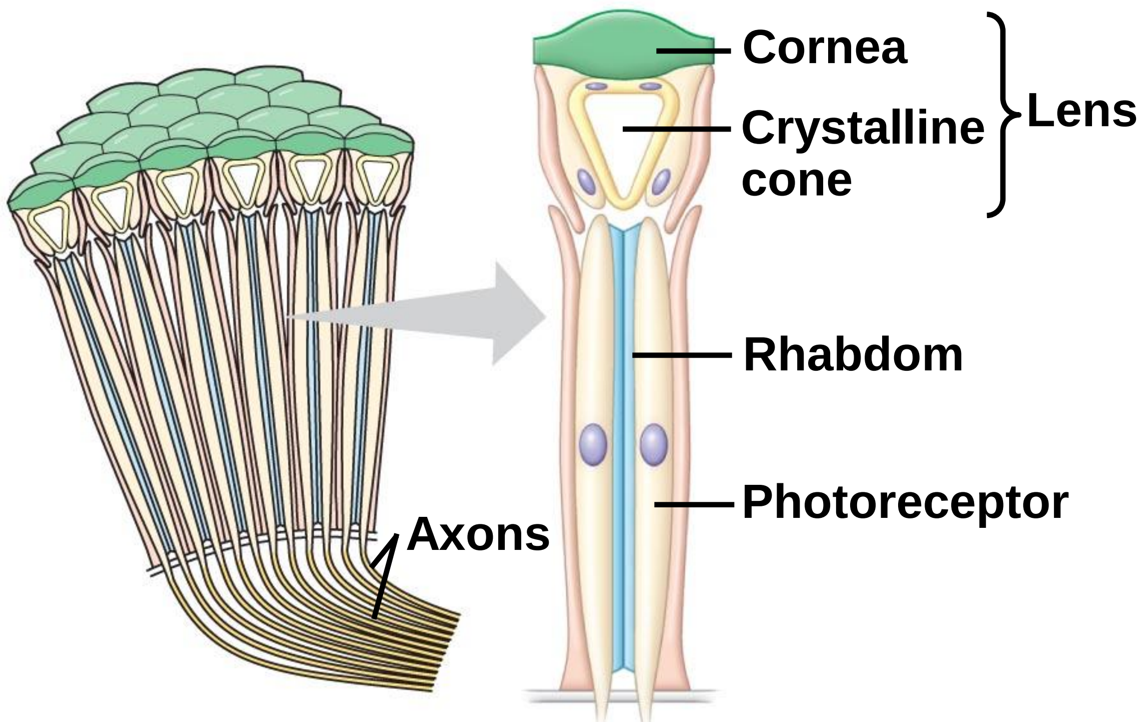


Fig. 50-17

(a) Fly eyes



(b) Ommatidia

Fig. 50-18

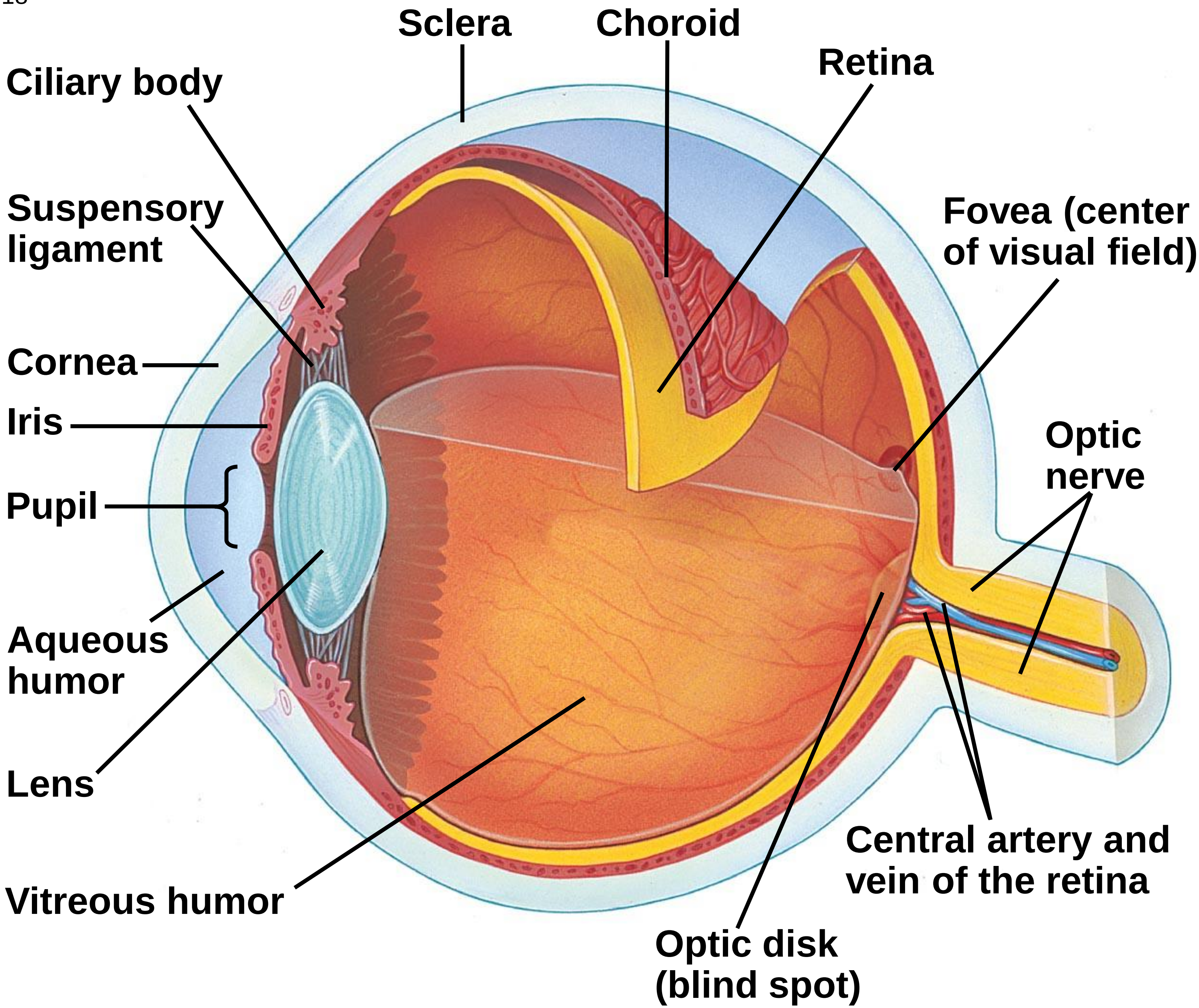

Sclera
Choroid
Retina
Ciliary body
Suspensory ligament
Cornea
Iris
Pupil
Aqueous humor
Lens
Vitreous humor
Fovea (center of visual field)
Optic nerve
Central artery and vein of the retina
Optic disk (blind spot)

Fig. 50-19

Focusing in the mammalian eye

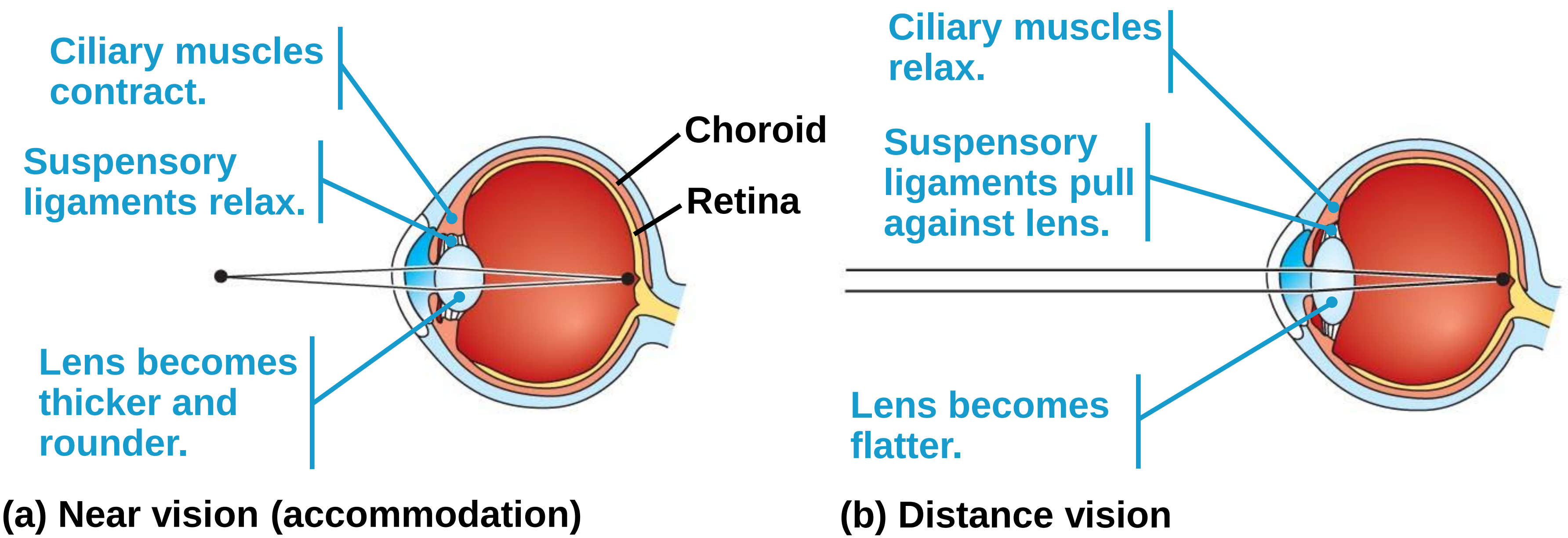


Fig. 50-20

Activation of rhodopsin by light

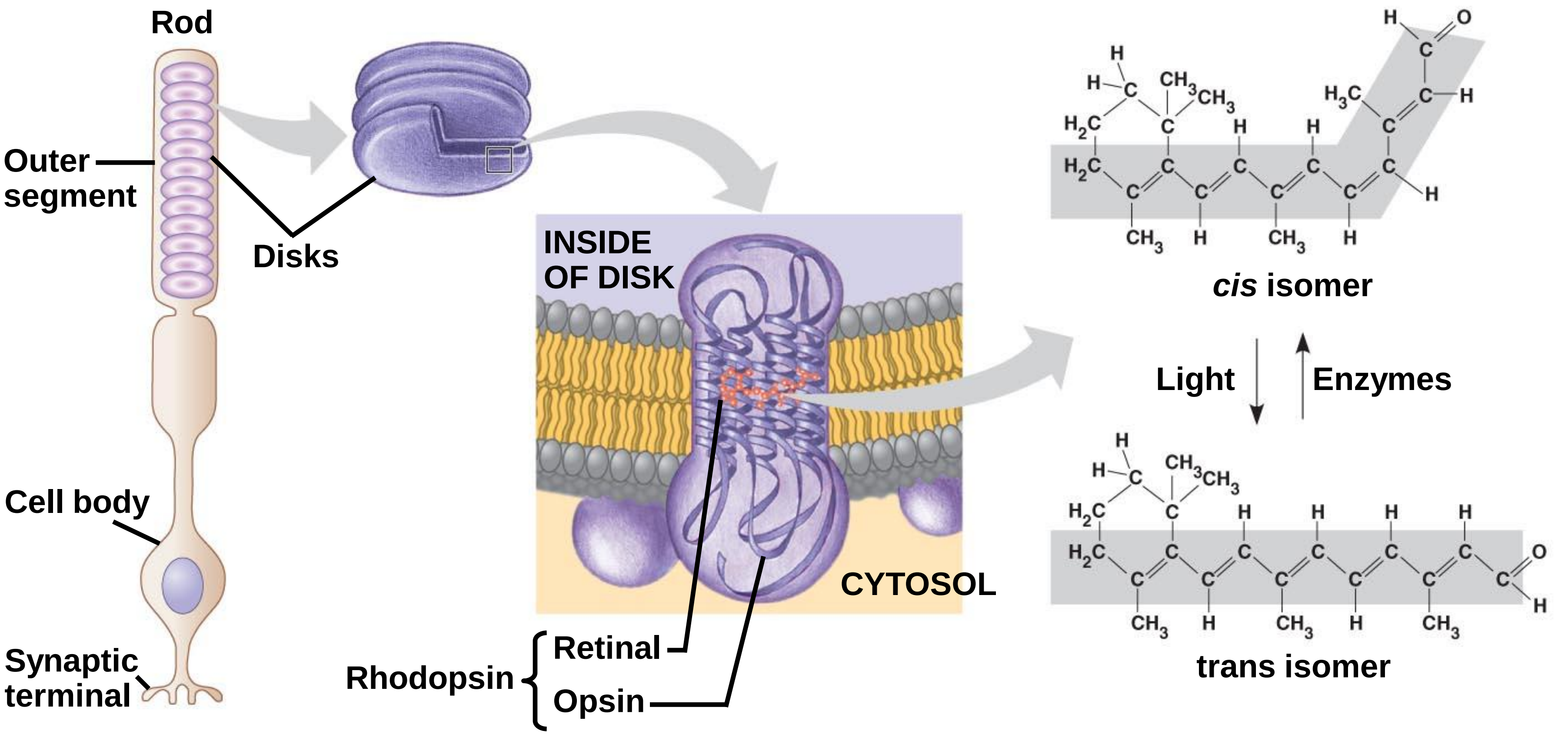


Fig. 50-21

Receptor potential production in a rod cell

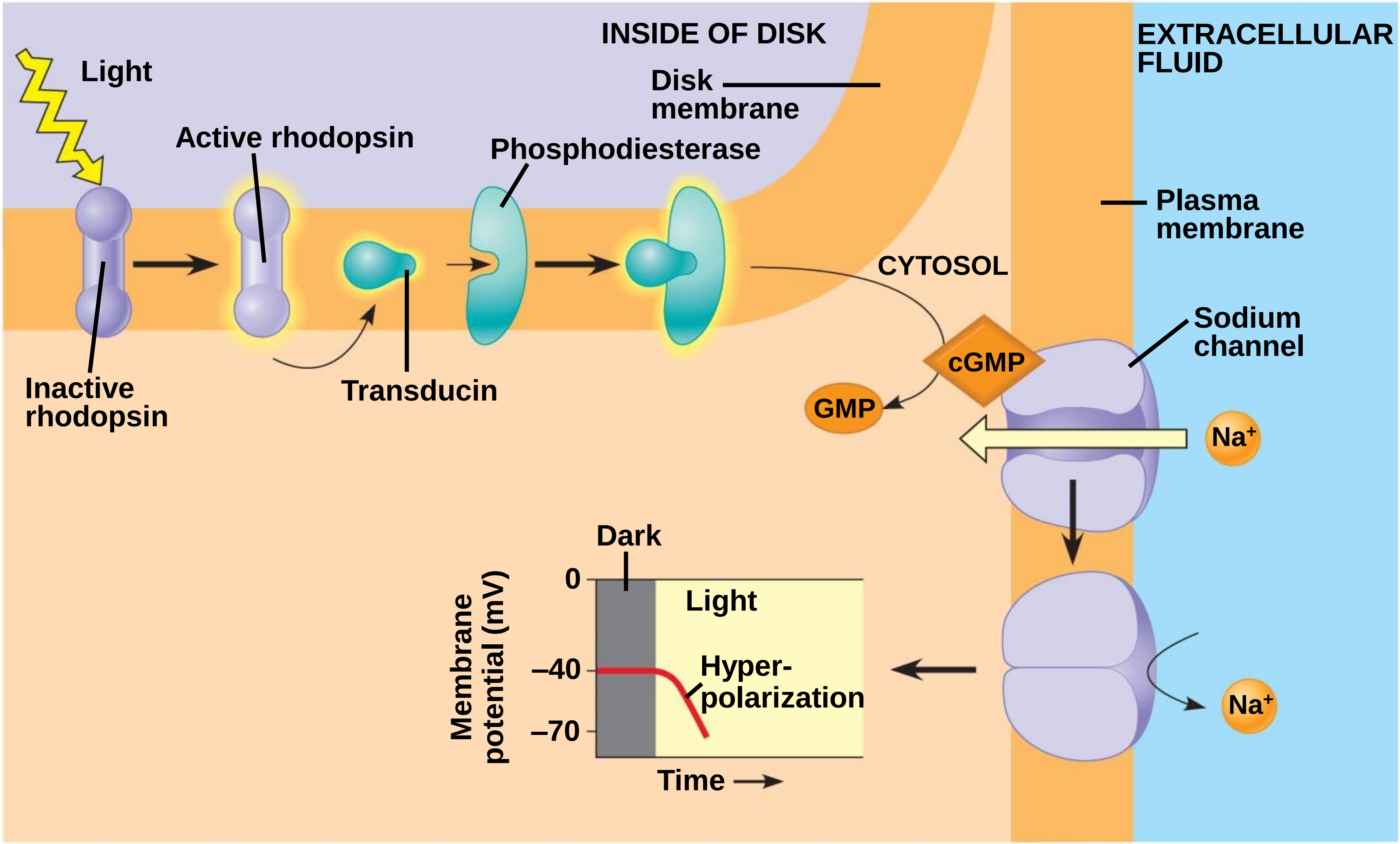


Fig. 50-22

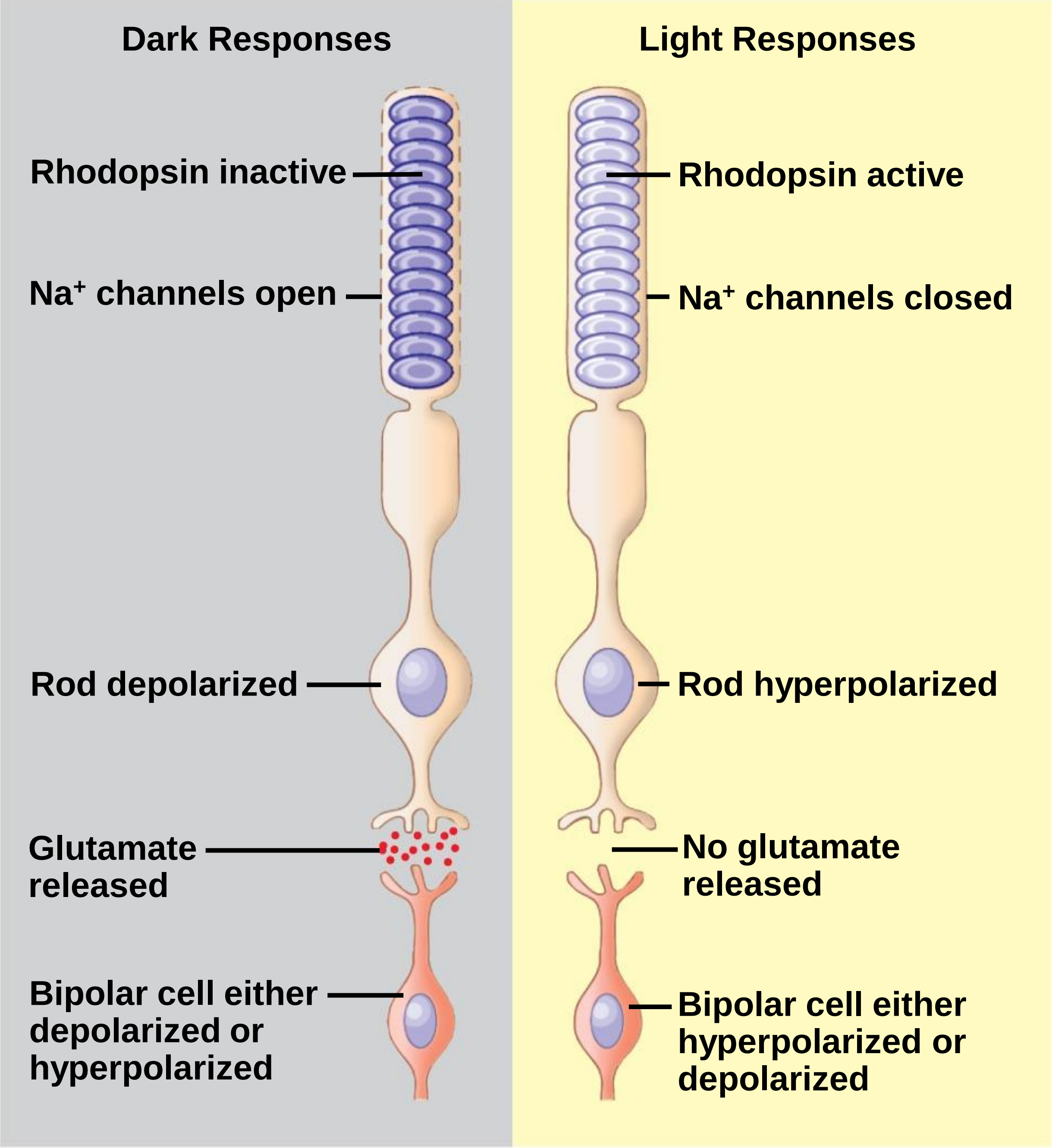
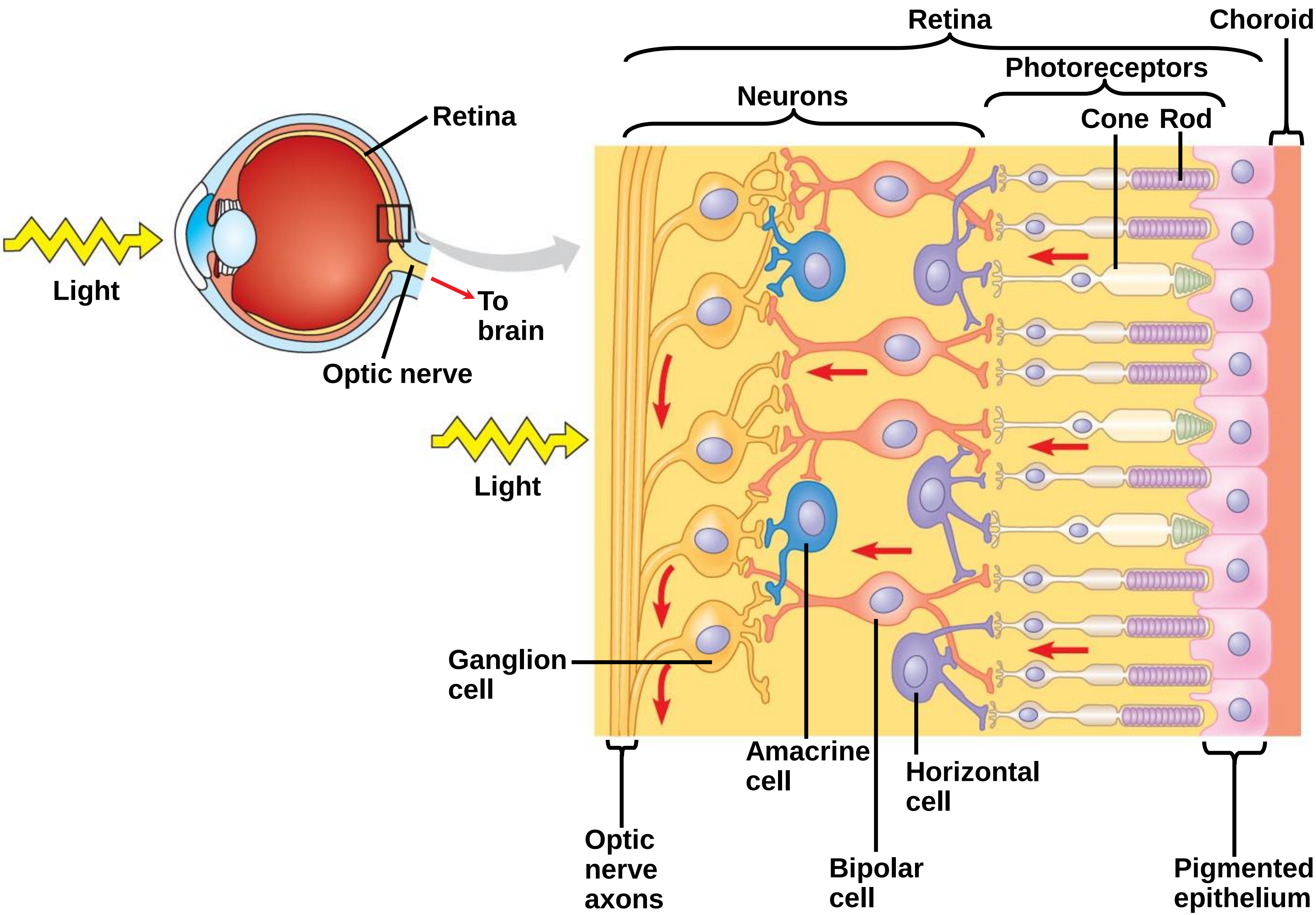
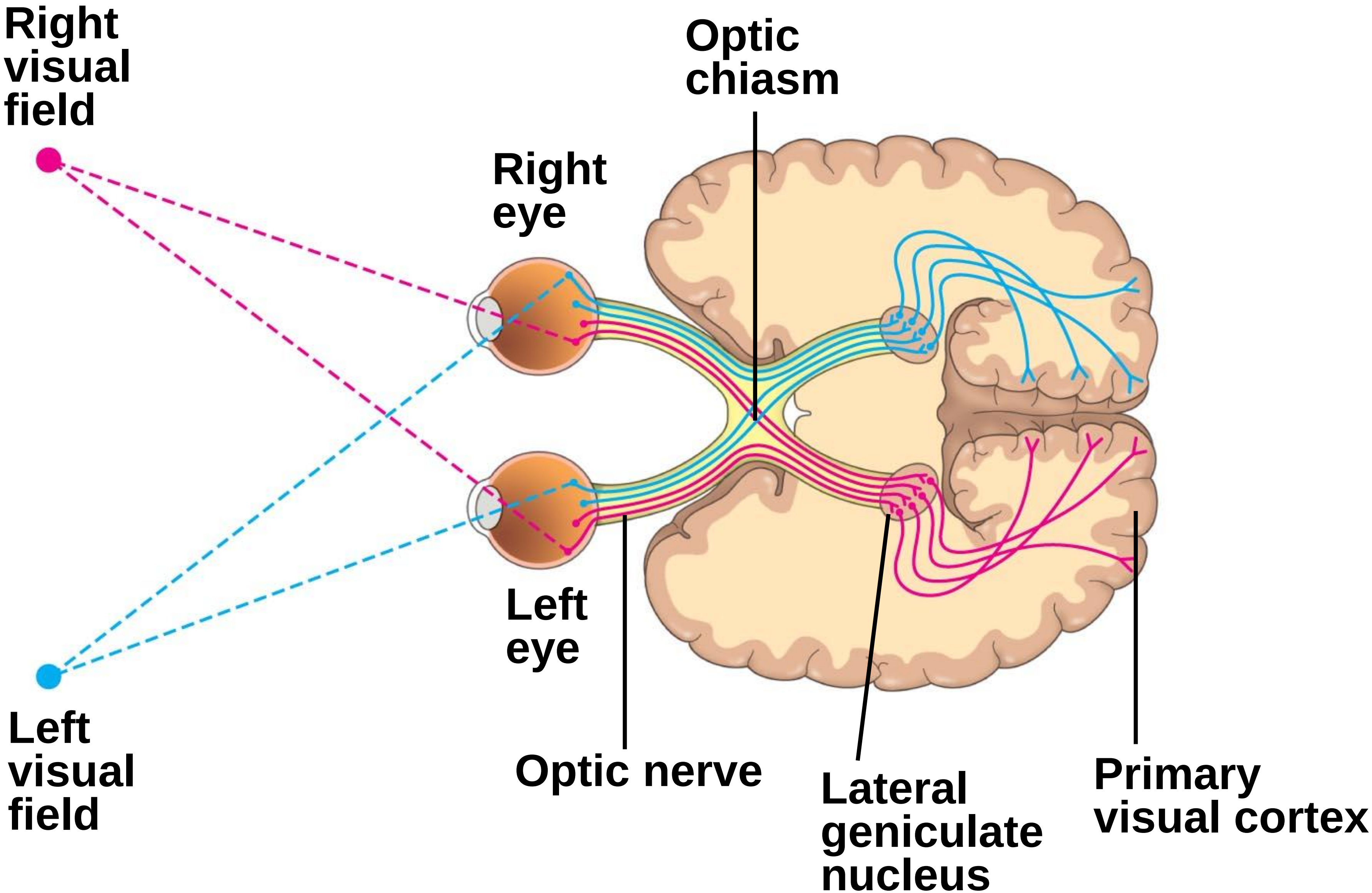

Dark Responses
Light Responses
Rhodopsin inactive
Na+ channels open
Rod depolarized
Glutamate released
Bipolar cell either depolarized or hyperpolarized
Rhodopsin active
Na+ channels closed
Rod hyperpolarized
No glutamate released
Bipolar cell either hyperpolarized or depolarized

Fig. 50-23



Light
Retina
To brain
Optic nerve
Retina
Choroid
Photoreceptors
Neurons
Cone
Rod
Light
Ganglion cell
Amacrine cell
Horizontal cell
Optic nerve axons
Bipolar cell
Pigmented epithelium

Fig. 50-24



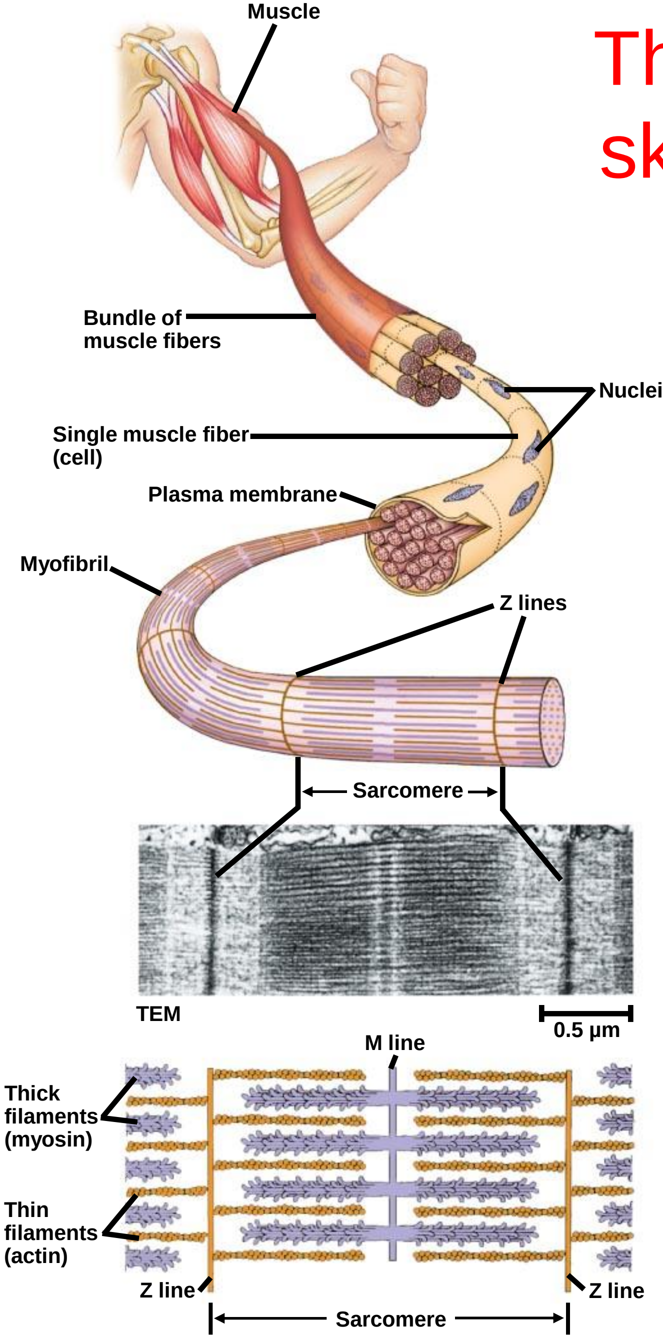
Right visual field
Optic chiasm
Right eye
Left eye
Left visual field
Optic nerve
Lateral geniculate nucleus
Primary visual cortex

Evolution of Visual Perception

- Photoreceptors in diverse animals likely originated in the earliest bilateral animals
- Melanopsin, a pigment in ganglion cells, may play a role in circadian rhythms in humans

Fig. 50-25

The structure of skeletal muscle



According to the **sliding-filament model**, filaments slide past each other longitudinally, producing more overlap between thin and thick filaments

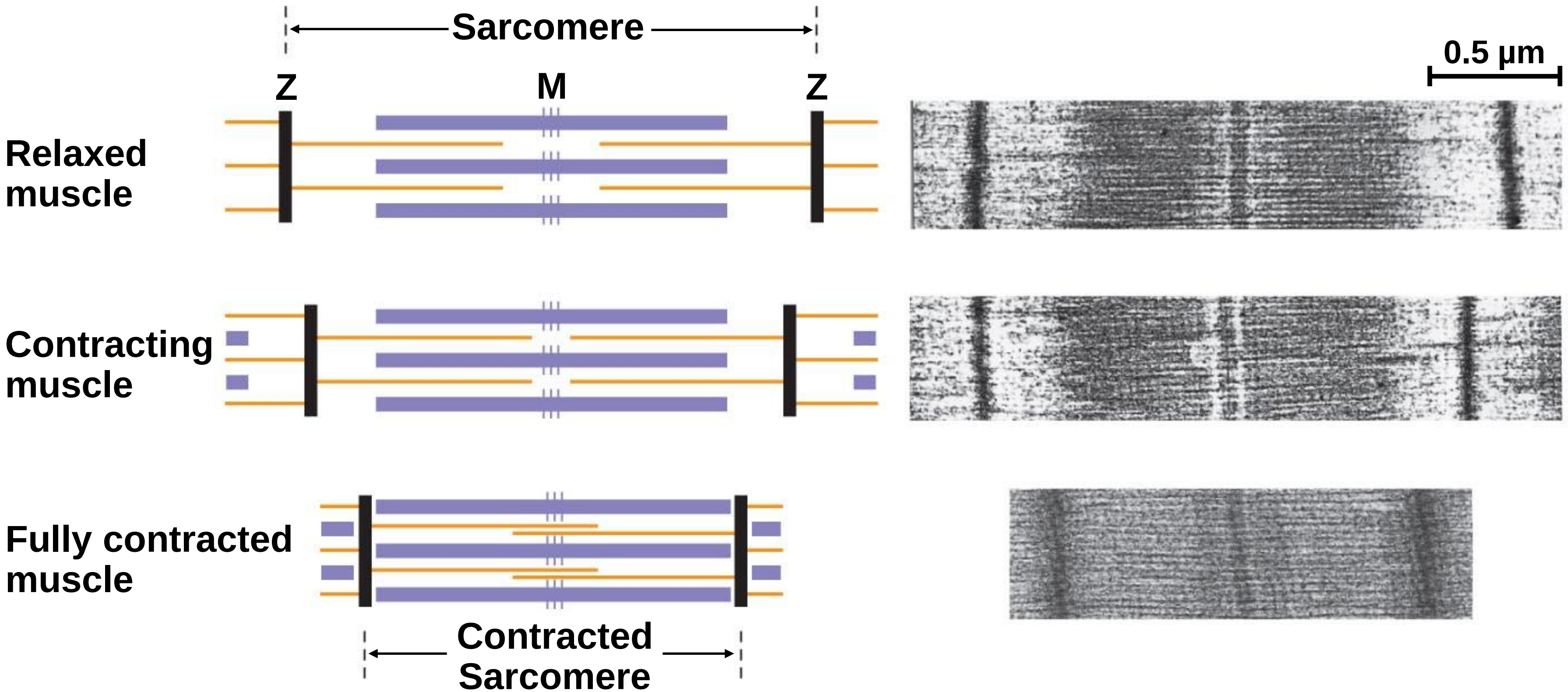


Fig. 50-27-4

Myosin-actin interactions underlying muscle fiber contraction

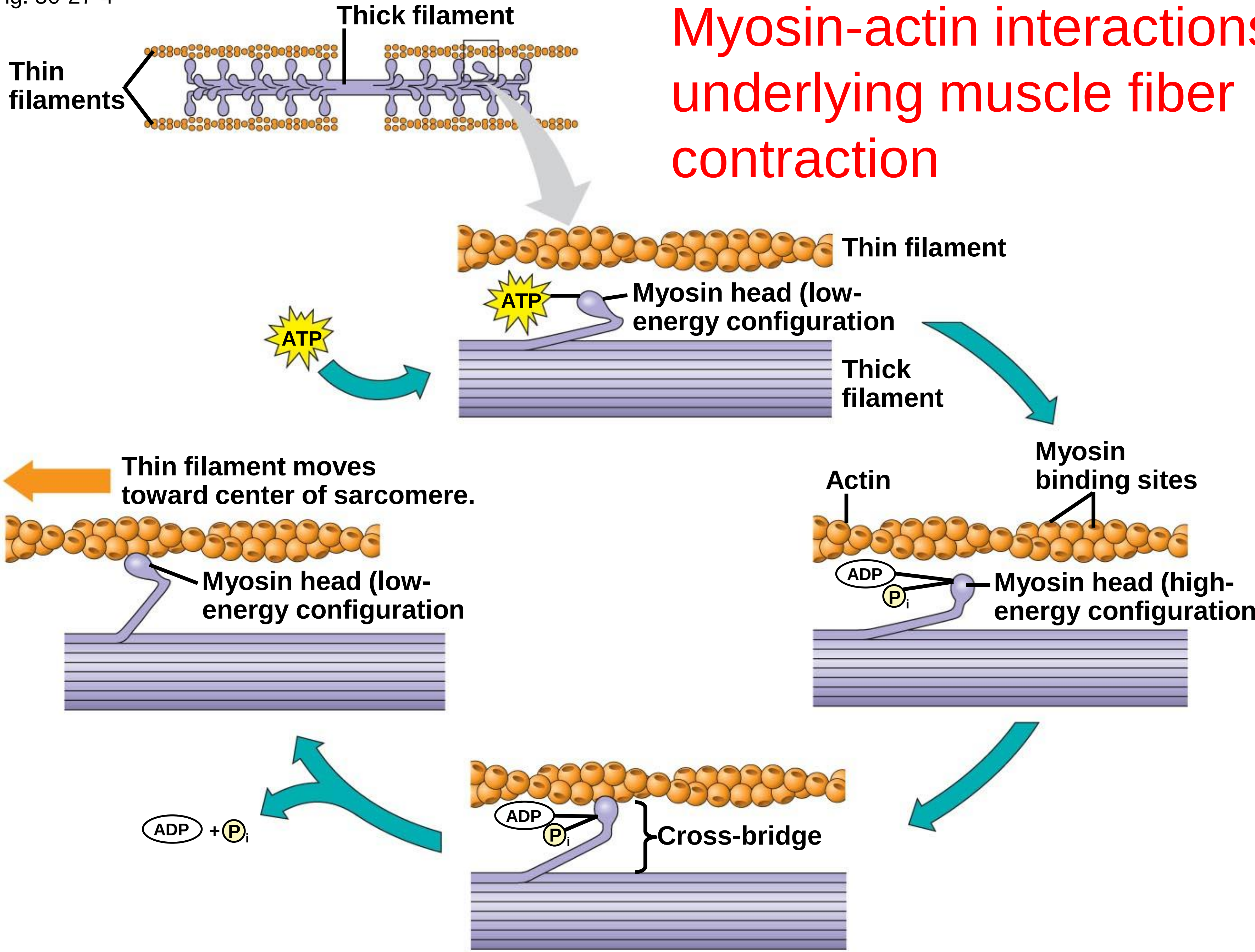
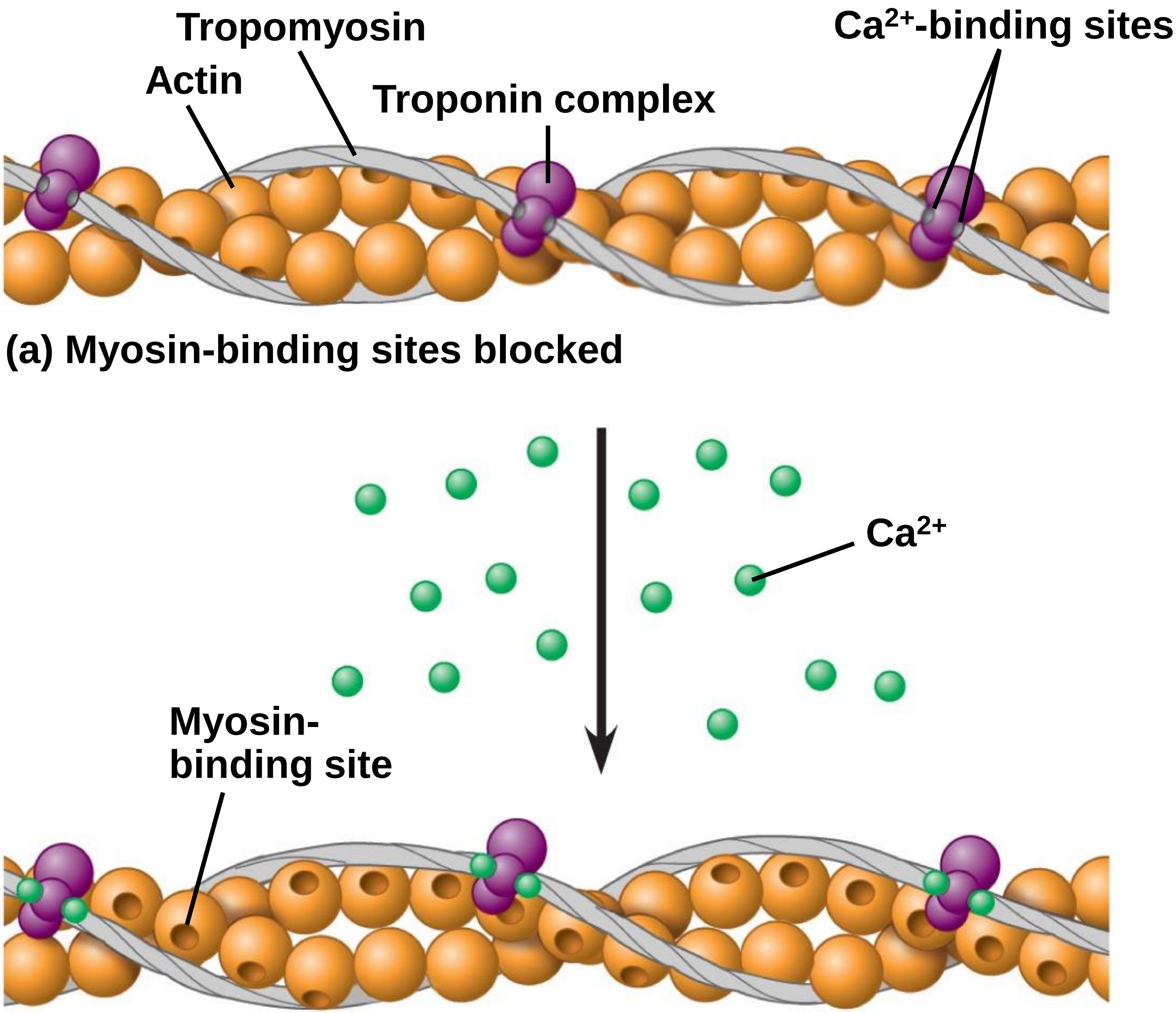


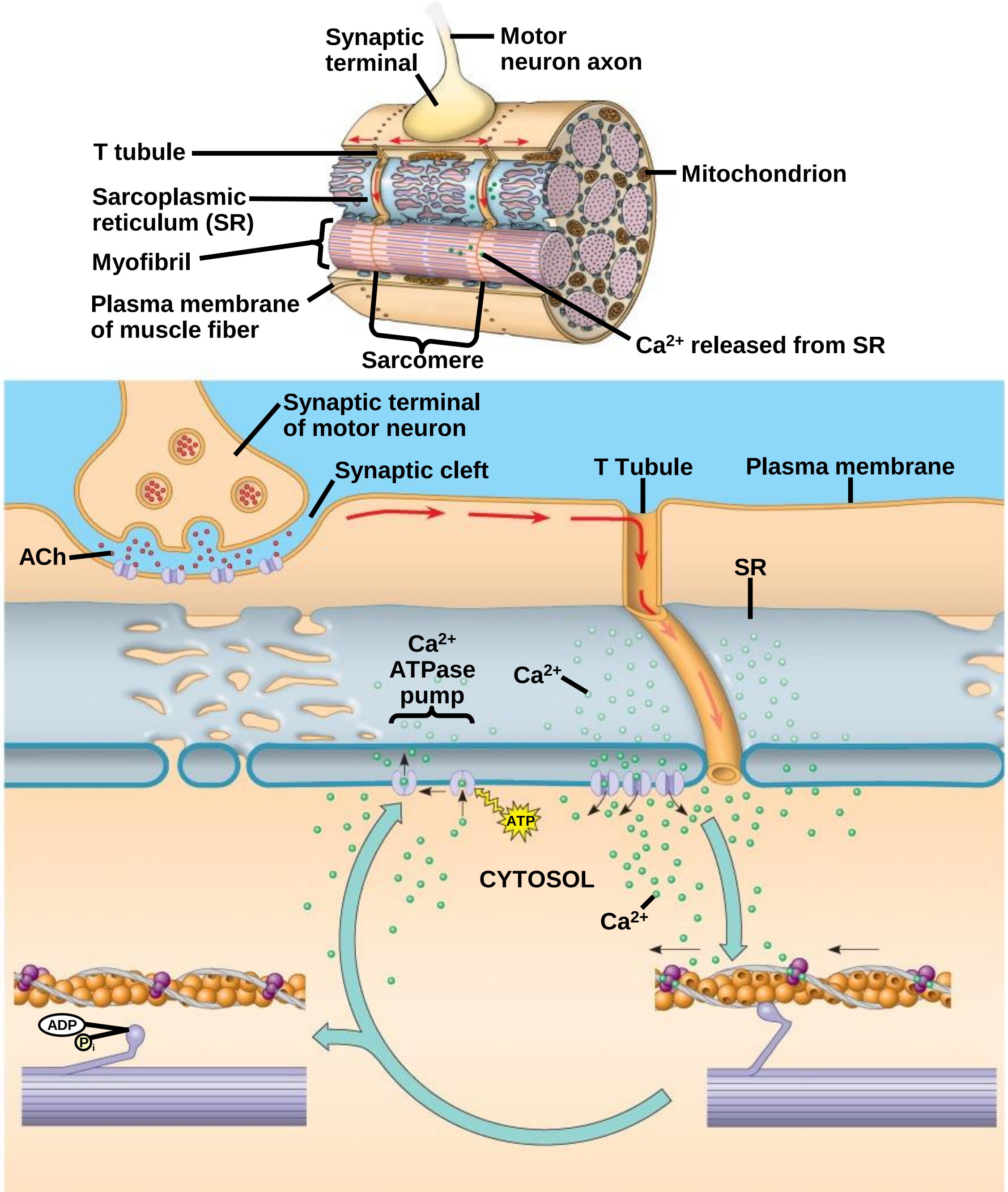
Fig. 50-28



(a) Myosin-binding sites blocked

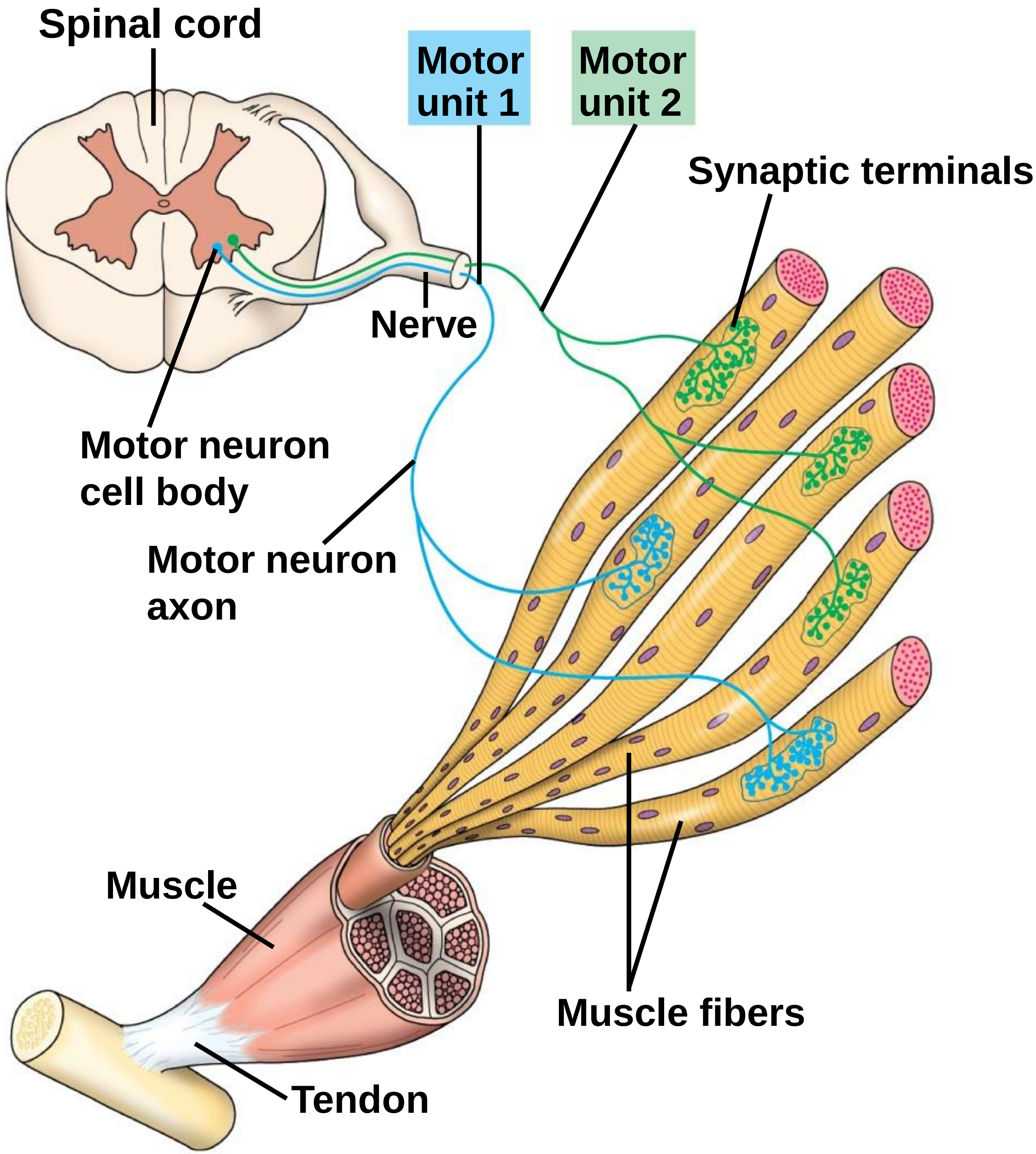
(b) Myosin-binding sites exposed

Fig. 50-29



Synaptic terminal
Motor neuron axon
T tubule
Mitochondrion
Sarcoplasmic reticulum (SR)
Myofibril
Plasma membrane of muscle fiber
Sarcomere
Ca²⁺ released from SR
Synaptic terminal of motor neuron
Synaptic cleft
T Tubule
Plasma membrane
ACh
SR
Ca²⁺ ATPase pump
Ca²⁺
ATP
CYTOSOL
Ca²⁺
ADP
P i

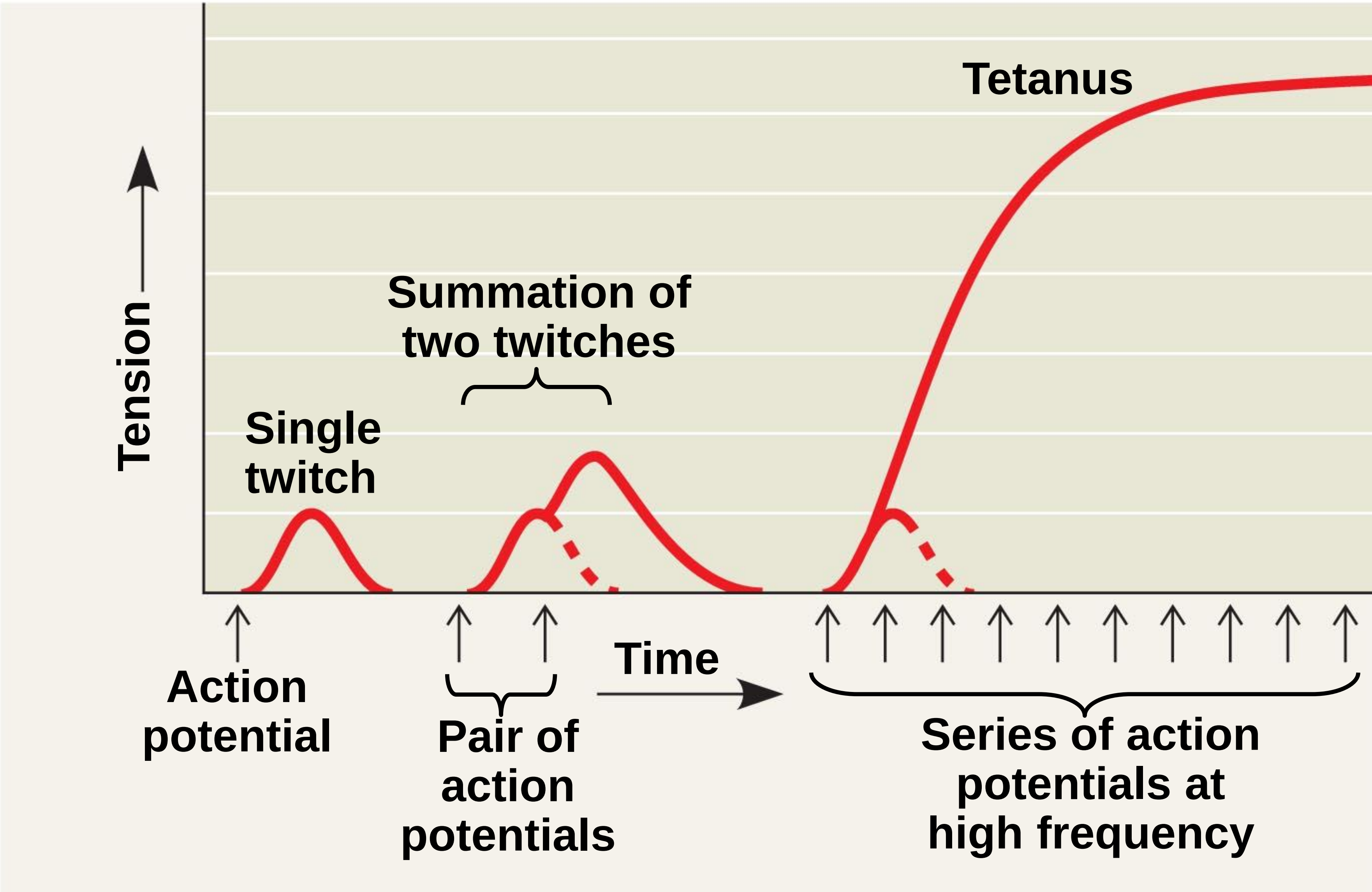
Fig. 50-30



Spinal cord
Motor unit 1
Motor unit 2
Synaptic terminals
Nerve
Motor neuron cell body
Motor neuron axon
Muscle
Muscle fibers
Tendon

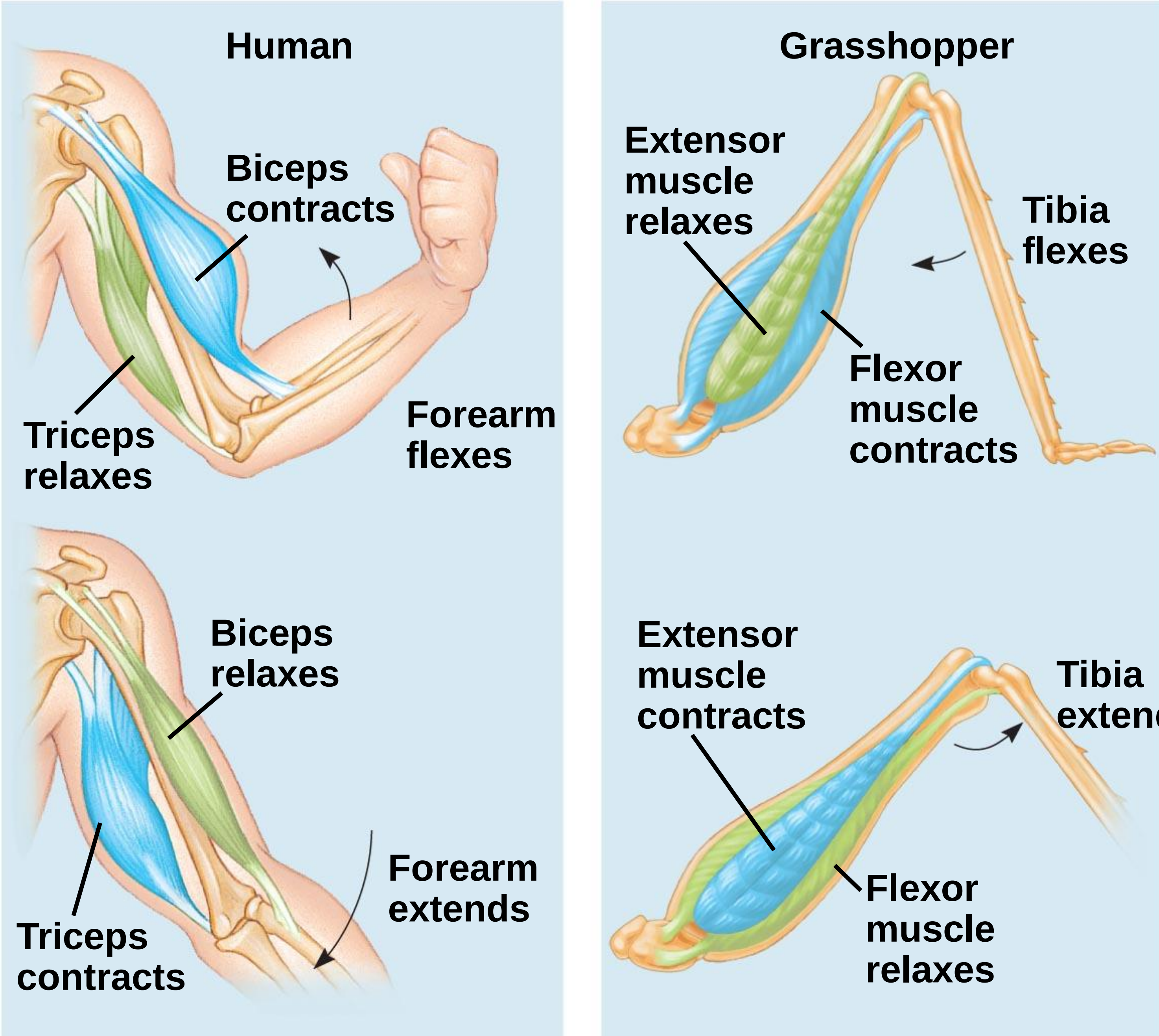
Fig. 50-31

Summation of twitches



- Oxidative fibers rely on aerobic respiration to generate ATP
- Glycolytic fibers use glycolysis as their primary source of ATP
- Glycolytic fibers have less myoglobin than oxidative fibers, and tire more easily
- In poultry and fish, light meat is composed of glycolytic fibers, while dark meat is composed of oxidative fibers

Fig. 50-32



Human
Biceps contracts
Triceps relaxes
Forearm flexes
Biceps relaxes
Triceps contracts
Forearm extends
Grasshopper
Extensor muscle relaxes
Tibia flexes
Flexor muscle contracts
Extensor muscle contracts
Tibia extends
Flexor muscle relaxes

Types of Skeletal Systems

- The three main types of skeletons are:
  - Hydrostatic skeletons (lack hard parts)
  - Exoskeletons (external hard parts)
  - Endoskeletons (internal hard parts)

Fig. 50-33

Crawling by peristalsis

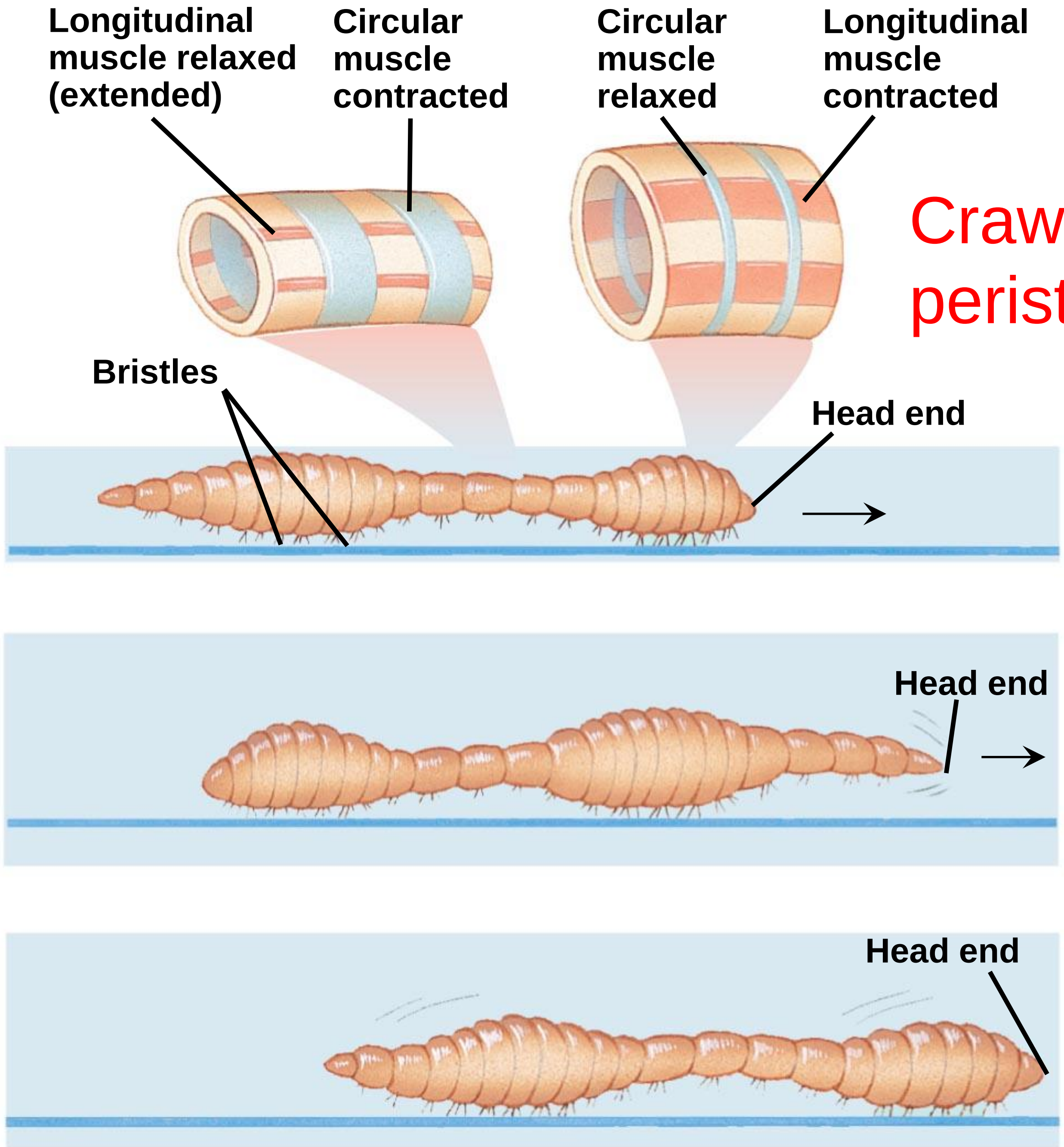


Fig. 50-34

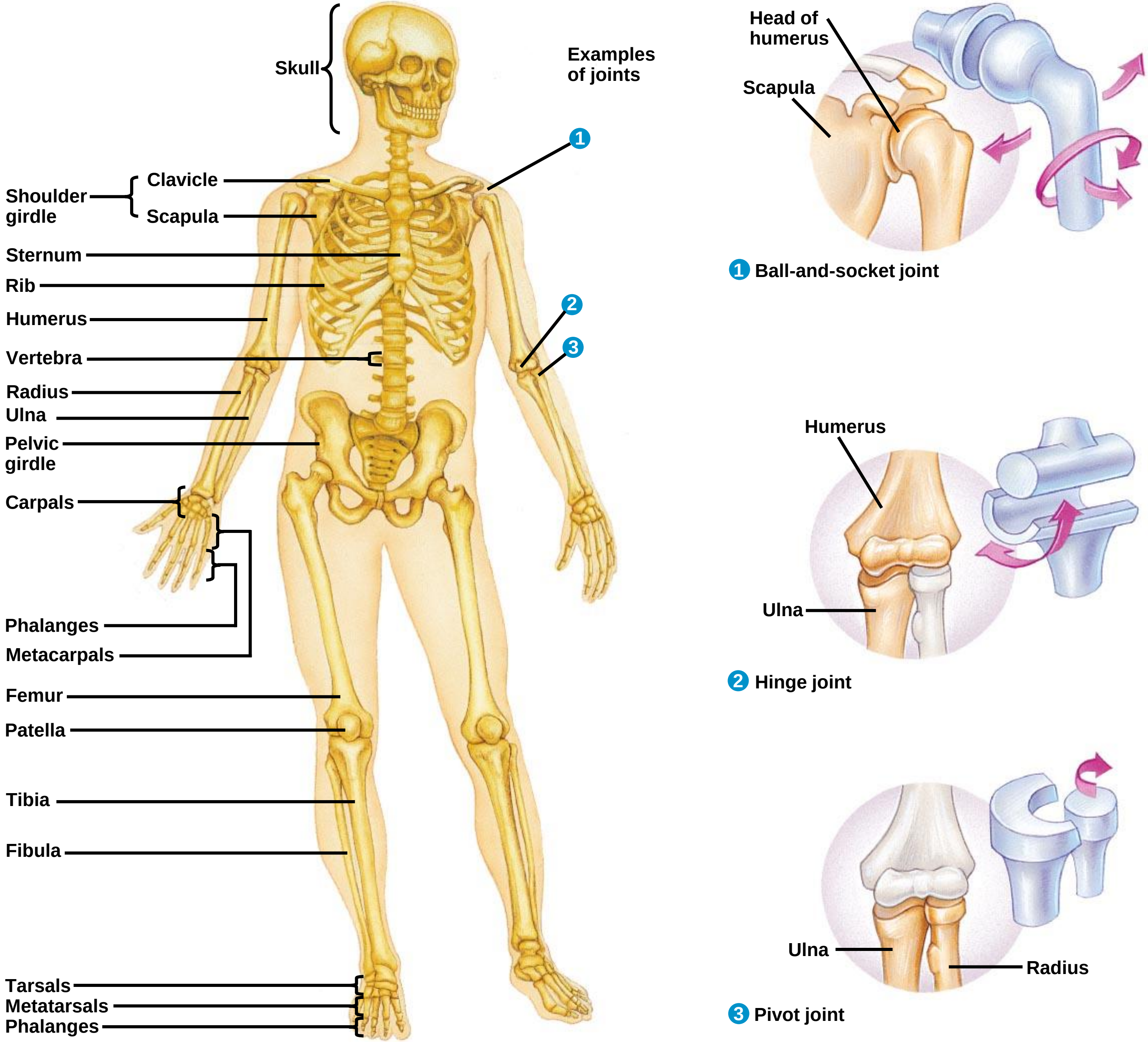

Skull
Examples of joints
Shoulder girdle
Clavicle
Scapula
Sternum
Rib
Humerus
Vertebra
Radius
Ulna
Pelvic girdle
Carpals
Phalanges
Metacarpals
Femur
Patella
Tibia
Fibula
Tarsals
Metatarsals
Phalanges
Head of humerus
Scapula
1 Ball-and-socket joint
Humerus
Ulna
2 Hinge joint
Ulna
Radius
3 Pivot joint

Fig. 50-35

Energy-efficient locomotion on land

Fig. 50-36

Measuring energy usage during flight

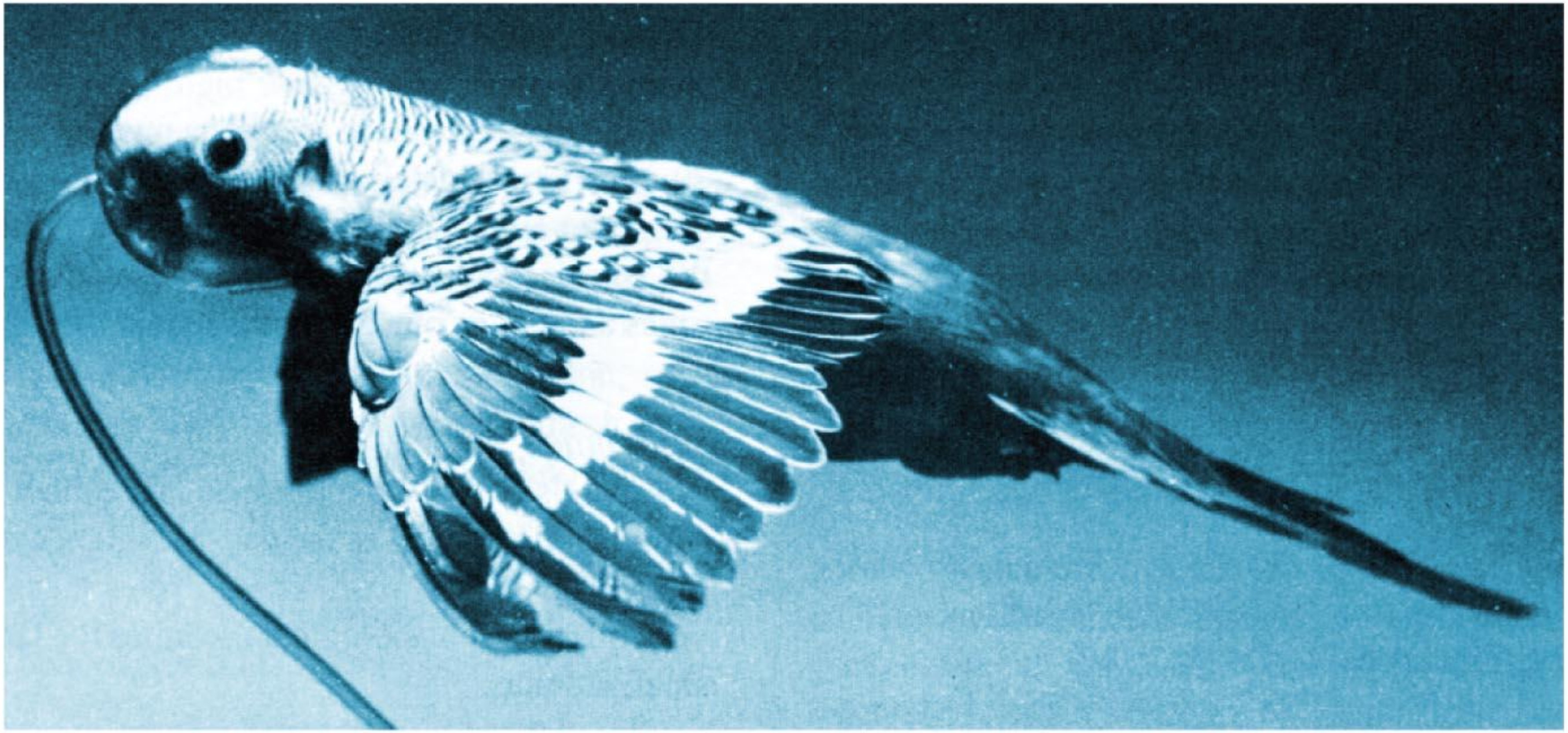
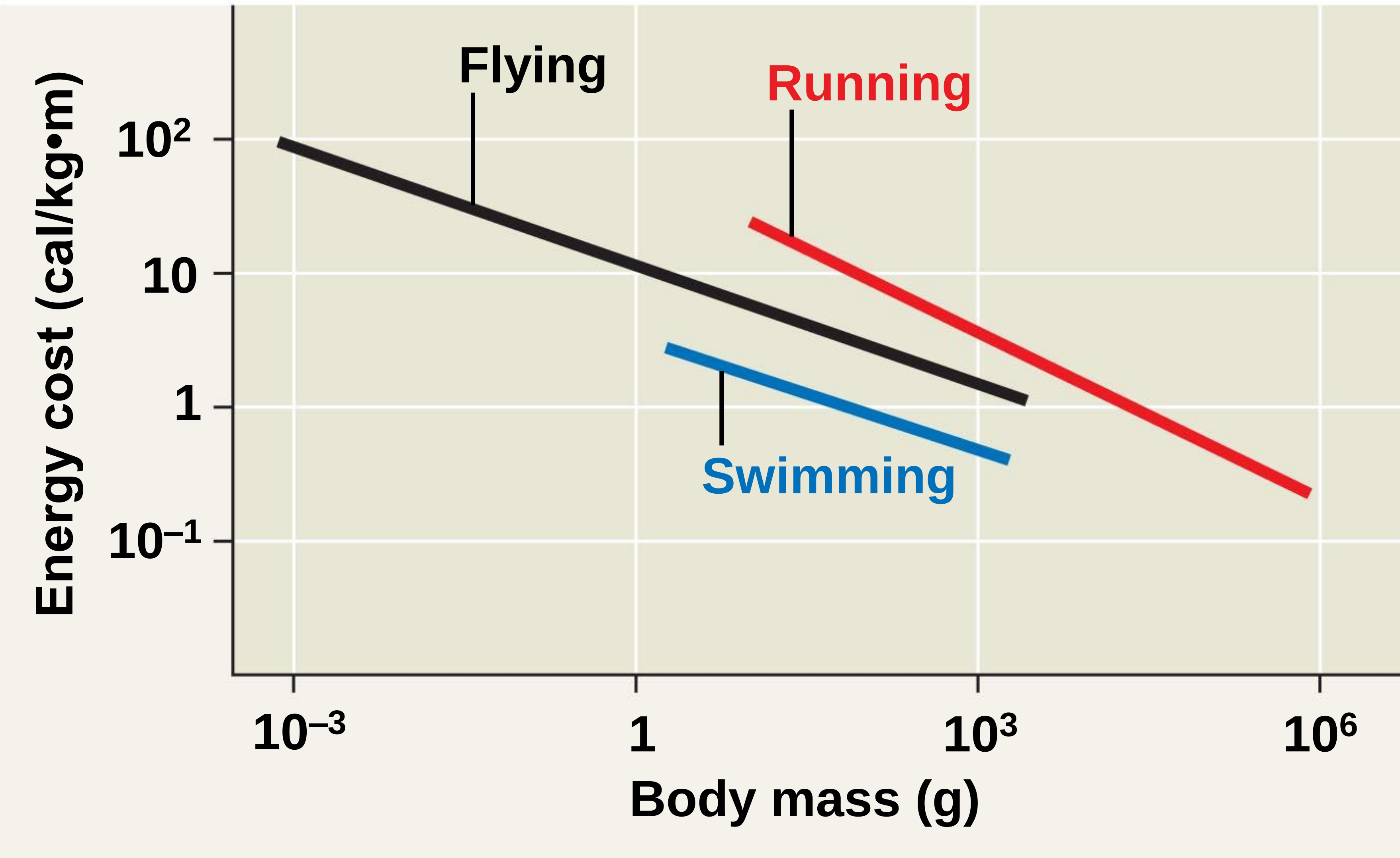


Fig. 50-37

RESULTS

Animals specialized for swimming expend less energy per meter traveled than equivalently sized animals specialized for flying or running



You should now be able to:

1. Distinguish between the following pairs of terms: sensation and perception; sensory transduction and receptor potential; tastants and odorants; rod and cone cells; oxidative and glycolytic muscle fibers; slow-twitch and fast-twitch muscle fibers; endoskeleton and exoskeleton

2. List the five categories of sensory receptors and explain the energy transduced by each type

3. Explain the role of mechanoreceptors in hearing and balance
4. Give the function of each structure using a diagram of the human ear
5. Explain the basis of the sensory discrimination of human smell
6. Identify and give the function of each structure using a diagram of the vertebrate eye

7. Identify the components of a skeletal muscle cell using a diagram
8. Explain the sliding-filament model of muscle contraction
9. Explain how a skeleton combines with an antagonistic muscle arrangement to provide a mechanism for movement