Action potential

- Definition: an “all-or-none” change in voltage that propagates itself down the axon

Action potential

- Definition: an “all-or-none” change in voltage that propagates itself down the axon
- Naturally occurring action potentials begin at the *axon hillock*

Action potential

- Definition: an “all-or-none” change in voltage that propagates itself down the axon
- Naturally occurring action potentials begin at the *axon hillock*
- Action potentials do not occur anywhere else in a neuron – not in dendrites, not in cell bodies

Figure 48.9 The role of voltage-gated ion channels in the action potential (Layer 5)

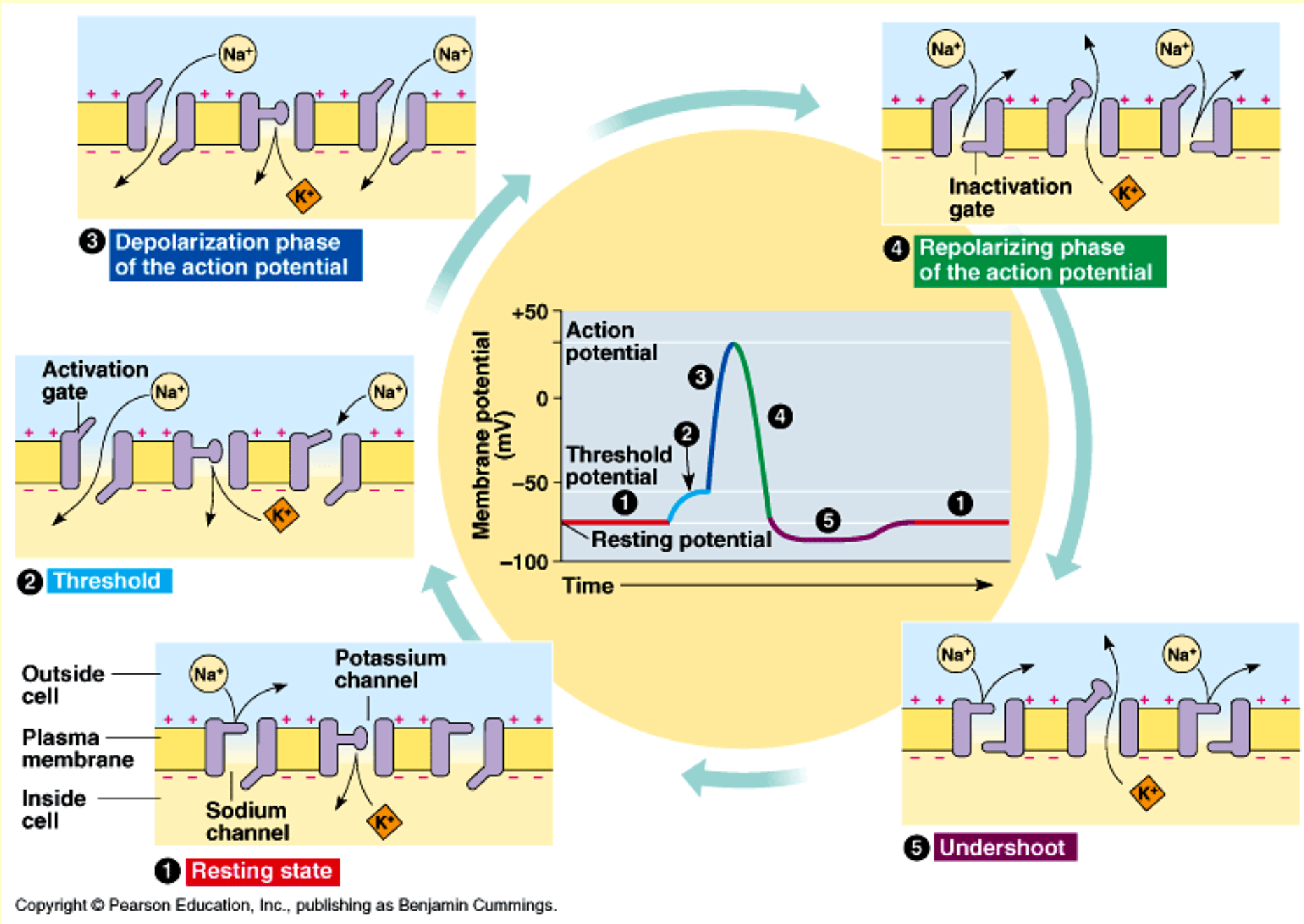
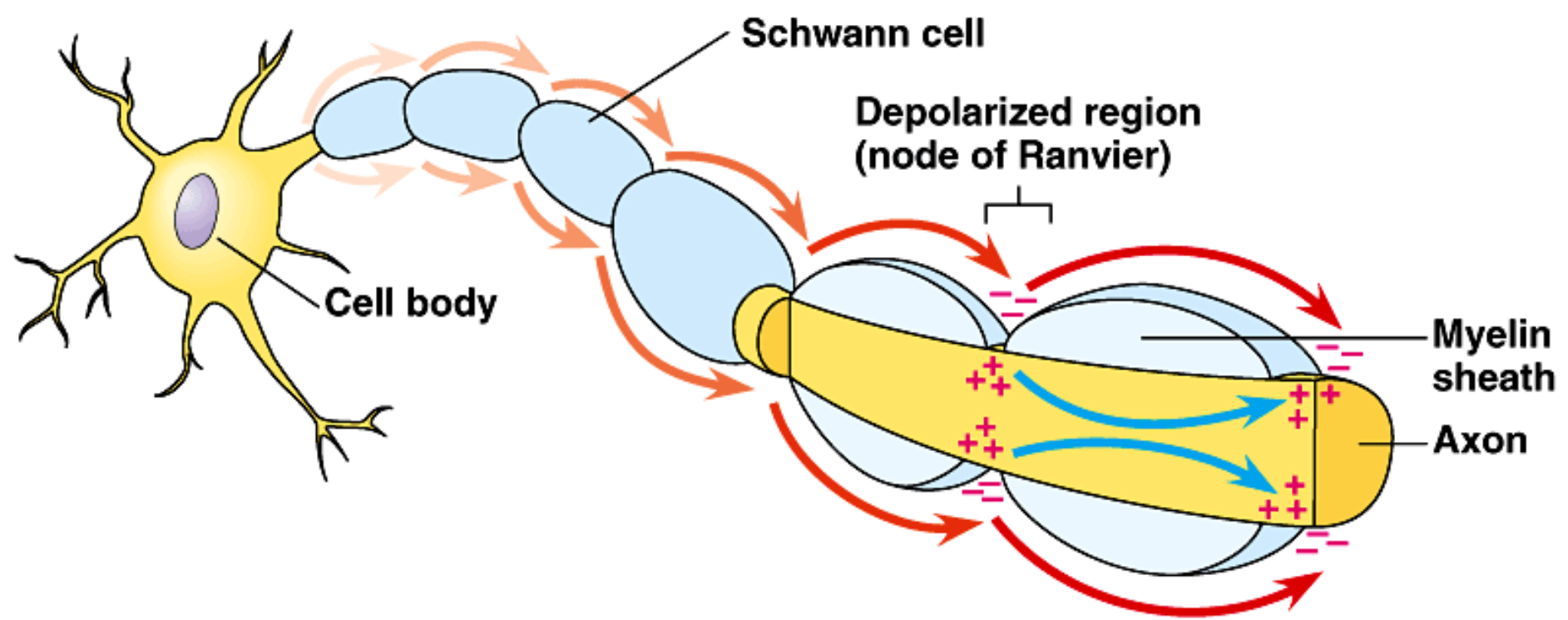


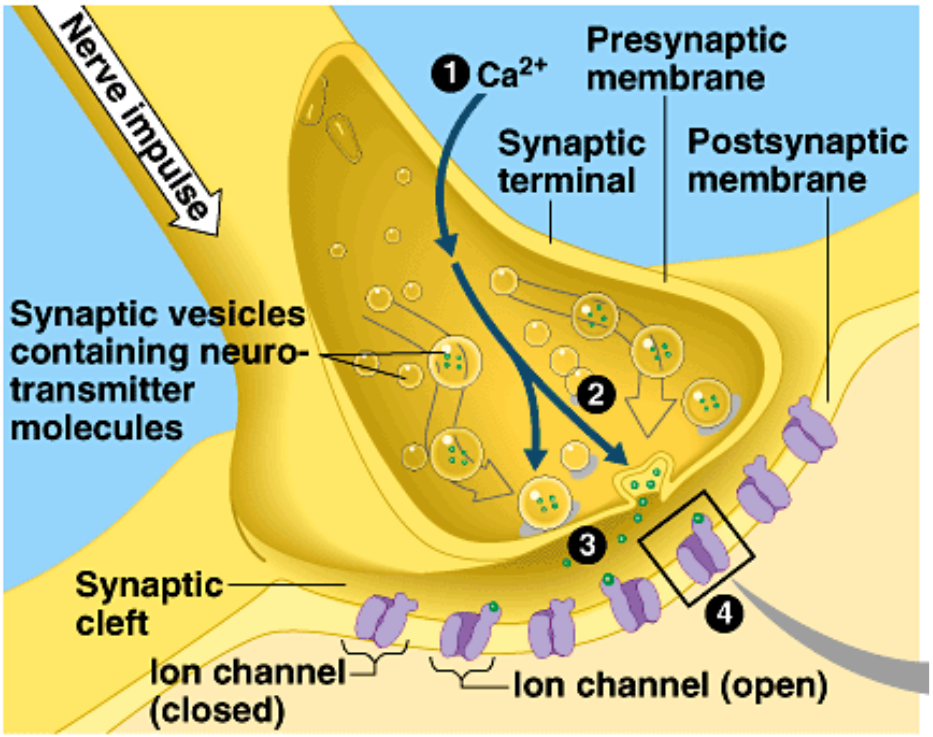
Figure 48.11 Saltatory conduction



How do you get from electrical signals to chemical signals and back again?

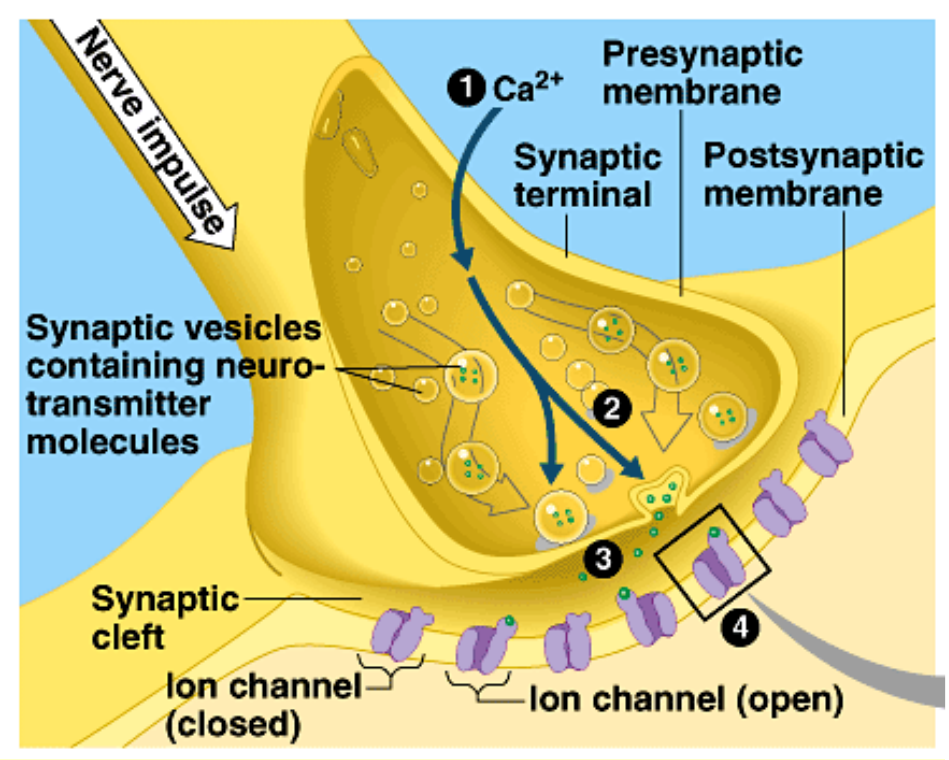
Translating signals

- The action potential moves down the axon until it reaches the terminal (synapse)



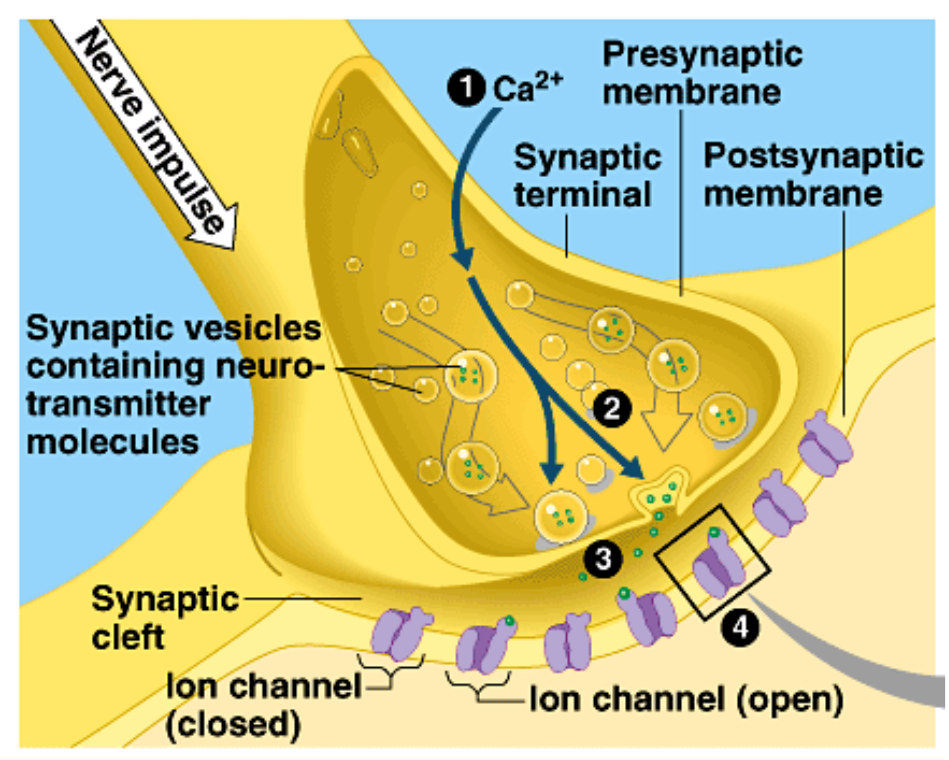
Translating signals

- The action potential moves down the axon until it reaches the terminal (synapse)
- Its wave of depolarization opens *voltage-activated Ca^{2+} channels*



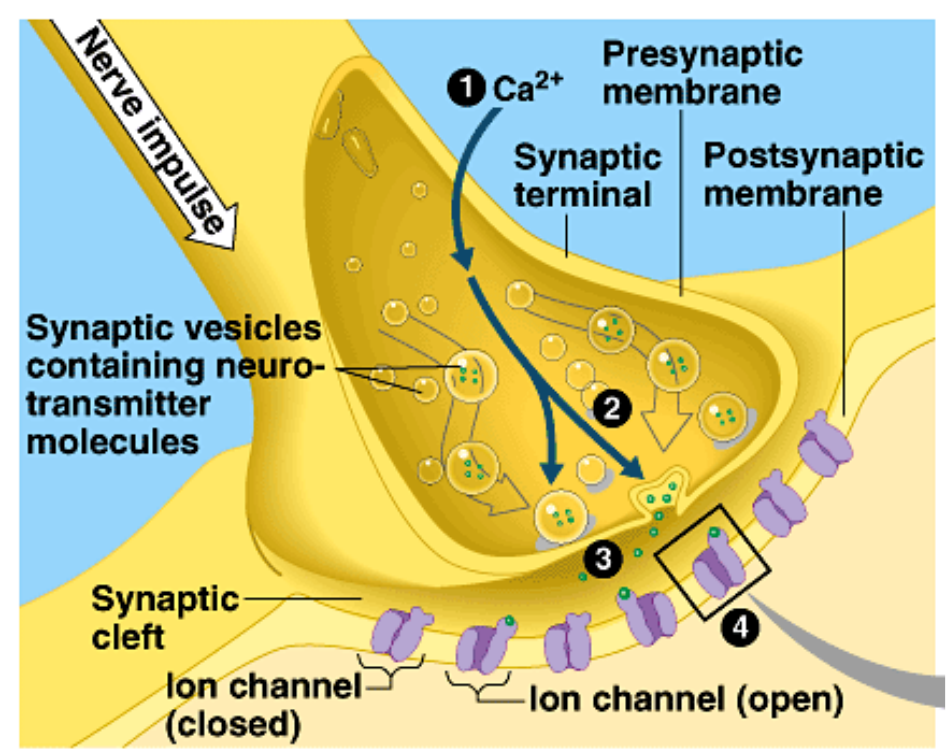
Translating signals

- The action potential moves down the axon until it reaches the terminal (synapse)
- Its wave of depolarization opens *voltage-activated Ca^{2+} channels*
- Influx of Ca^{2+} causes *vesicles* to fuse with presynaptic cell membrane



Translating signals

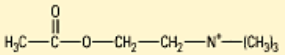
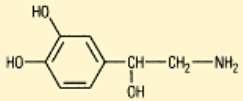
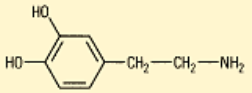
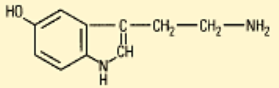
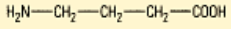
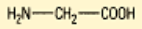
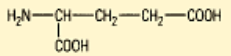
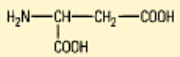
- The action potential moves down the axon until it reaches the terminal (synapse)
- Its wave of depolarization opens *voltage-activated Ca^{2+} channels*
- Influx of Ca^{2+} causes *vesicles* to fuse with presynaptic cell membrane
- Transmitter diffuses across synaptic cleft and binds to receptors on post-synaptic cell



Excitatory and inhibitory neurotransmitters

- If a transmitter depolarizes the post-synaptic neuron, it is said to be *excitatory*

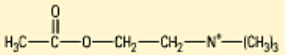
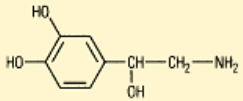
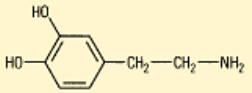
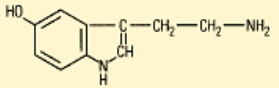
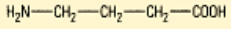
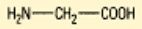
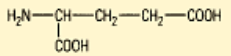
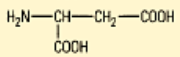
Table 48.1 The Major Known Neurotransmitters

Neurotransmitter	Structure	Functional Class
Acetylcholine		Excitatory to vertebrate skeletal muscles; excitatory or inhibitory at other sites
Biogenic Amines		
Norepinephrine		Excitatory or inhibitory
Dopamine		Generally excitatory; may be inhibitory at some sites
Serotonin		Generally inhibitory
Amino Acids		
GABA (gamma aminobutyric acid)		Inhibitory
Glycine		Inhibitory
Glutamate		Excitatory
Aspartate		Excitatory
Neuropeptides		
Substance P	Arg—Pro—Lys—Pro—Gln—Gln—Phe—Phe—Gly—Leu—Met	Excitatory
Met-enkephalin (an endorphin)	Tyr—Gly—Gly—Phe—Met	Generally inhibitory

Excitatory and inhibitory neurotransmitters

- If a transmitter depolarizes the post-synaptic neuron, it is said to be *excitatory*
- If a transmitter hyperpolarizes the post-synaptic neuron, it is said to be *inhibitory*

Table 48.1 The Major Known Neurotransmitters

Neurotransmitter	Structure	Functional Class
Acetylcholine		Excitatory to vertebrate skeletal muscles; excitatory or inhibitory at other sites
Biogenic Amines		
Norepinephrine		Excitatory or inhibitory
Dopamine		Generally excitatory; may be inhibitory at some sites
Serotonin		Generally inhibitory
Amino Acids		
GABA (gamma aminobutyric acid)		Inhibitory
Glycine		Inhibitory
Glutamate		Excitatory
Aspartate		Excitatory
Neuropeptides		
Substance P	Arg—Pro—Lys—Pro—Gln—Gln—Phe—Phe—Gly—Leu—Met	Excitatory
Met-enkephalin (an endorphin)	Tyr—Gly—Gly—Phe—Met	Generally inhibitory

Excitatory and inhibitory neurotransmitters

- If a transmitter depolarizes the post-synaptic neuron, it is said to be *excitatory*
- If a transmitter hyperpolarizes the post-synaptic neuron, it is said to be *inhibitory*
- *Whether a transmitter is excitatory or inhibitory depends on its receptor*

Table 48.1 The Major Known Neurotransmitters

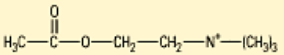
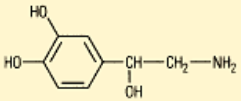
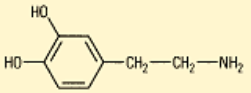
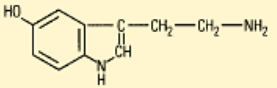
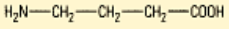
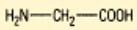
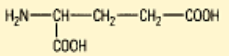
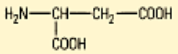
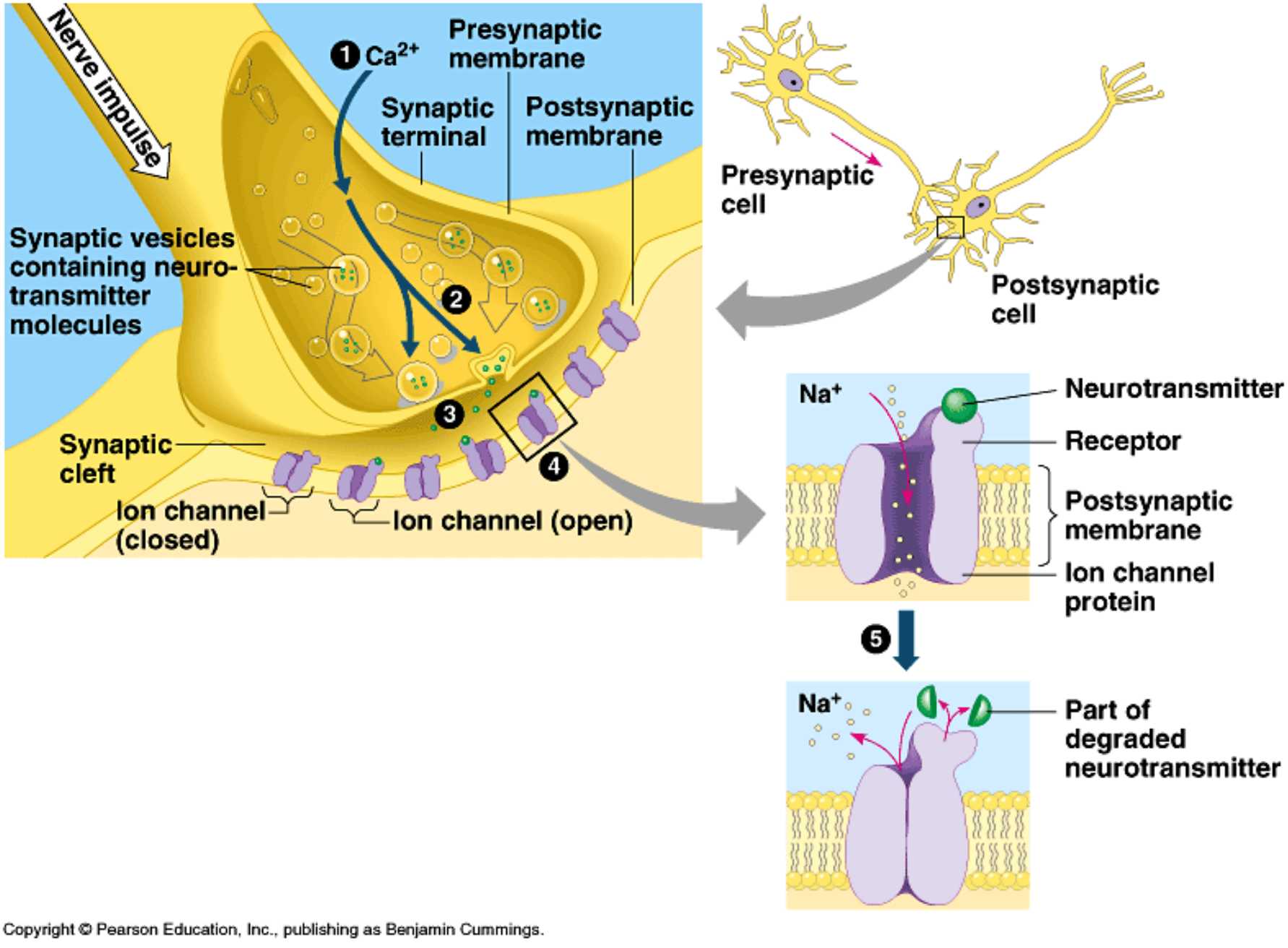
Neurotransmitter	Structure	Functional Class
Acetylcholine		Excitatory to vertebrate skeletal muscles; excitatory or inhibitory at other sites
Biogenic Amines		
Norepinephrine		Excitatory or inhibitory
Dopamine		Generally excitatory; may be inhibitory at some sites
Serotonin		Generally inhibitory
Amino Acids		
GABA (gamma aminobutyric acid)		Inhibitory
Glycine		Inhibitory
Glutamate		Excitatory
Aspartate		Excitatory
Neuropeptides		
Substance P	Arg—Pro—Lys—Pro—Gln—Gln—Phe—Phe—Gly—Leu—Met	Excitatory
Met-enkephalin (an endorphin)	Tyr—Gly—Gly—Phe—Met	Generally inhibitory

Figure 48.12 A chemical synapse



Excitatory and inhibitory neurotransmitters

- *Acetylcholine* is excitatory because its receptor is a *ligand-gated Na+ channel*

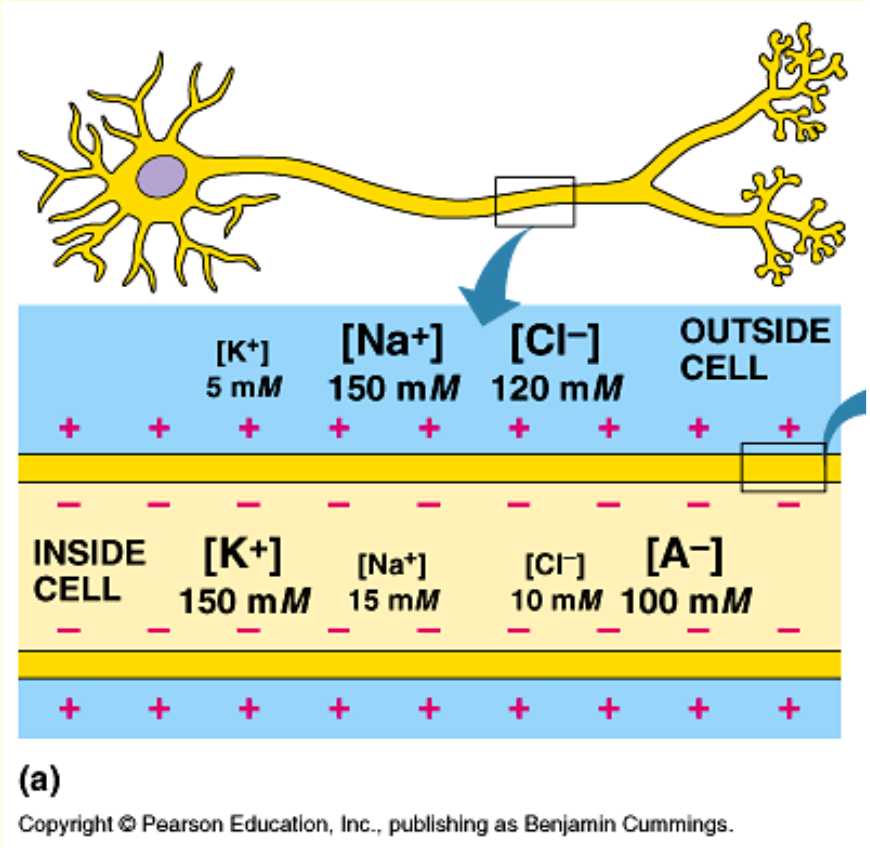


Fig 48.7

Excitatory and inhibitory neurotransmitters

- *Acetylcholine* is excitatory because its receptor is a *ligand-gated Na+ channel*
- *GABA* is inhibitory because its receptor is a *ligand-gated Cl- channel*

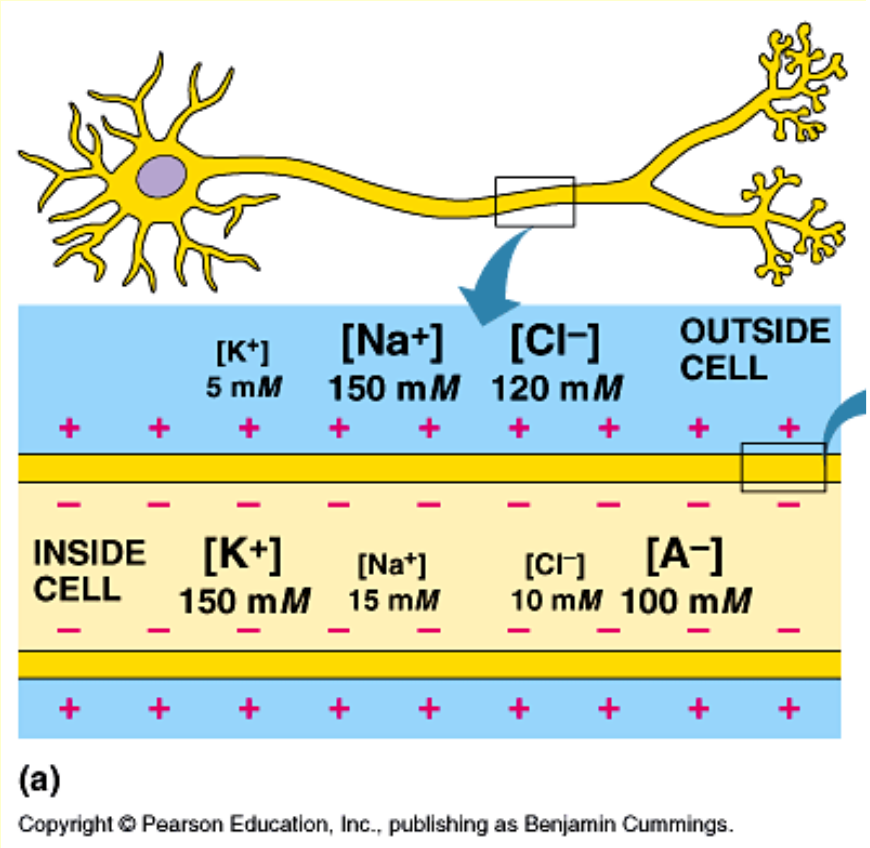


Fig 48.7

Excitatory and inhibitory neurotransmitters

- *Acetylcholine* is excitatory because its receptor is a *ligand-gated Na+ channel*
- *GABA* is inhibitory because its receptor is a *ligand-gated Cl- channel*
- Other transmitters (e.g. *vasopressin*) have *G-protein-linked receptors*

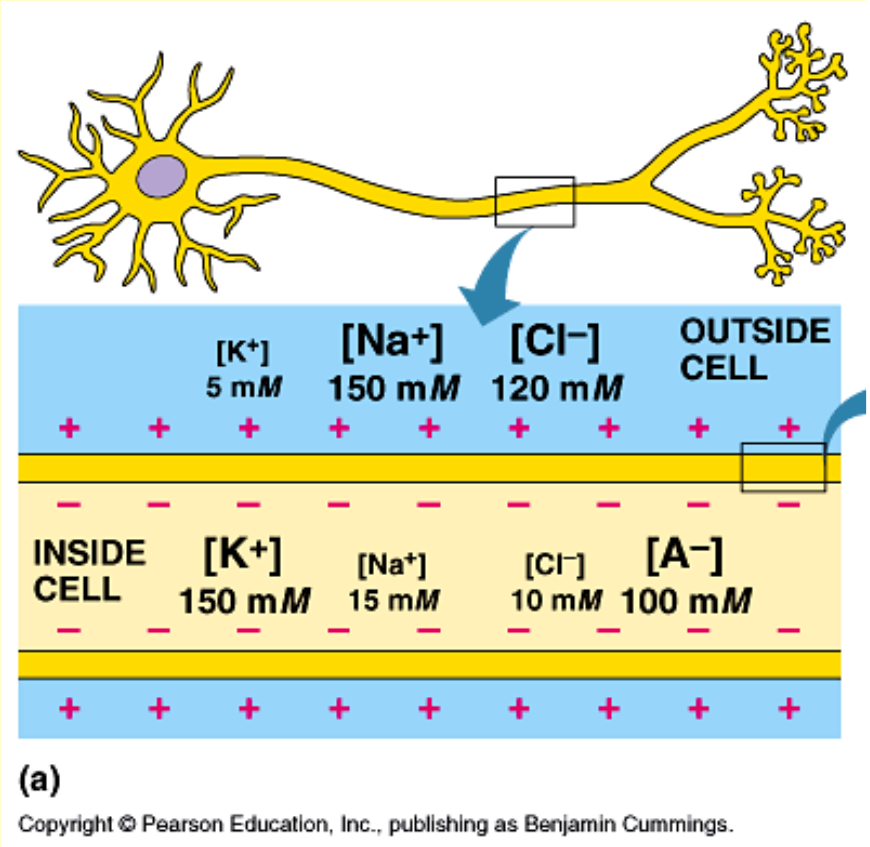


Fig 48.7

Excitatory and inhibitory neurotransmitters

- *Acetylcholine* is excitatory because its receptor is a *ligand-gated Na+ channel*
- *GABA* is inhibitory because its receptor is a *ligand-gated Cl- channel*
- Other transmitters (e.g. *vasopressin, dopamine*) have *G-protein-linked receptors*
  - Effects depend on the *signal transduction pathway* and cell type

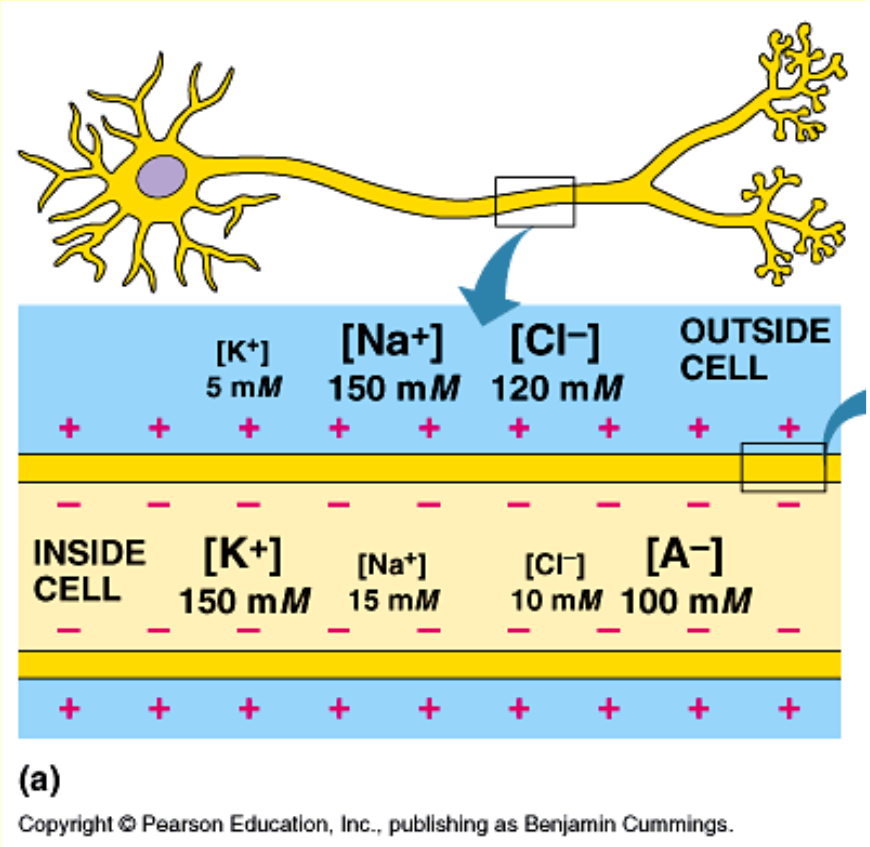
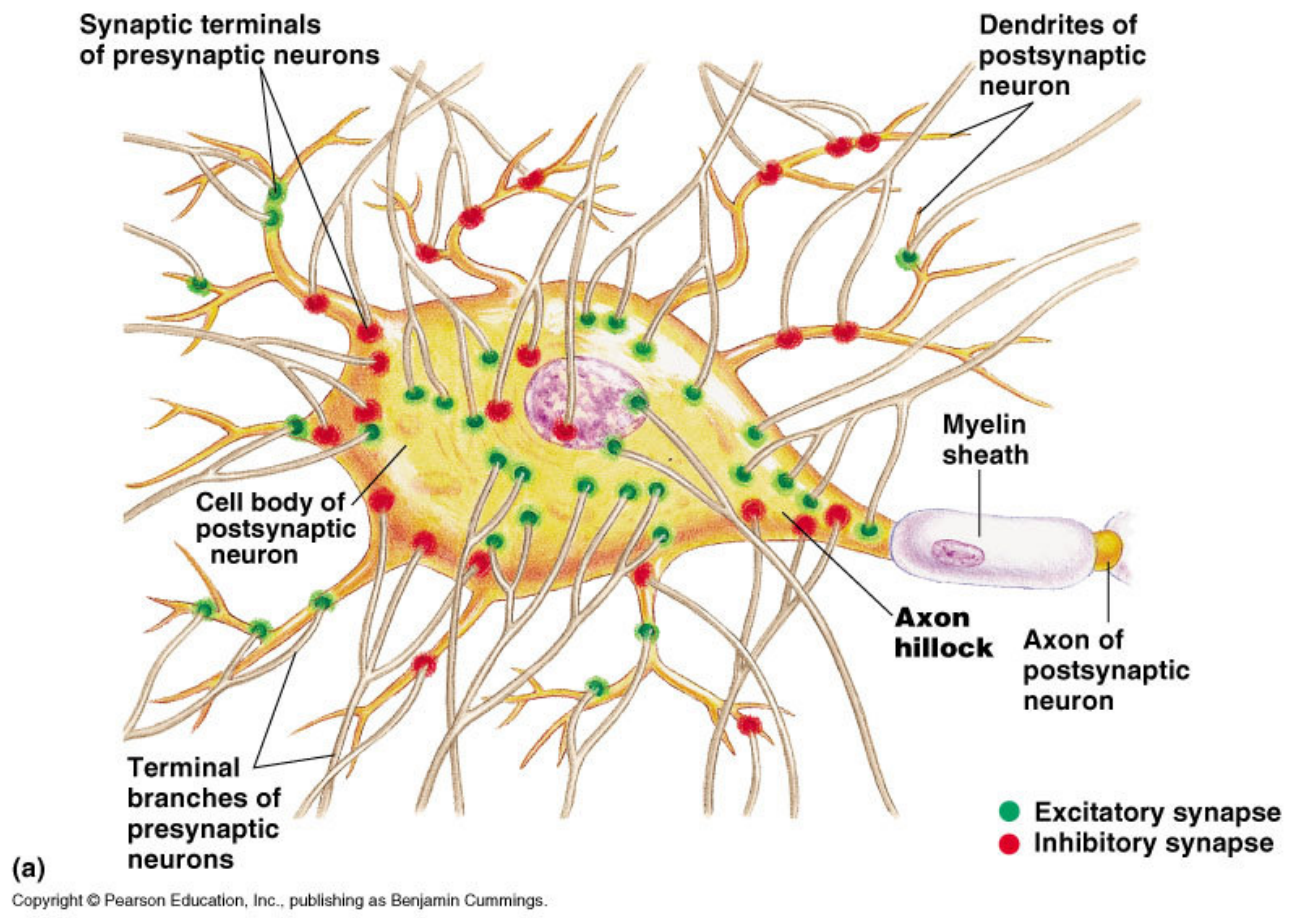


Fig 48.7

Some synapses form on the dendrites, cell body, or the axon hillock.



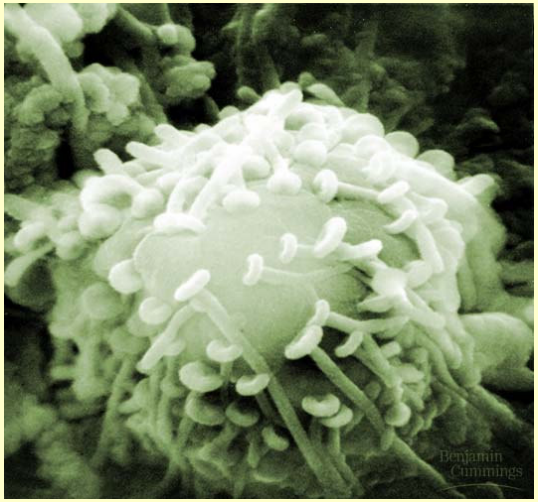
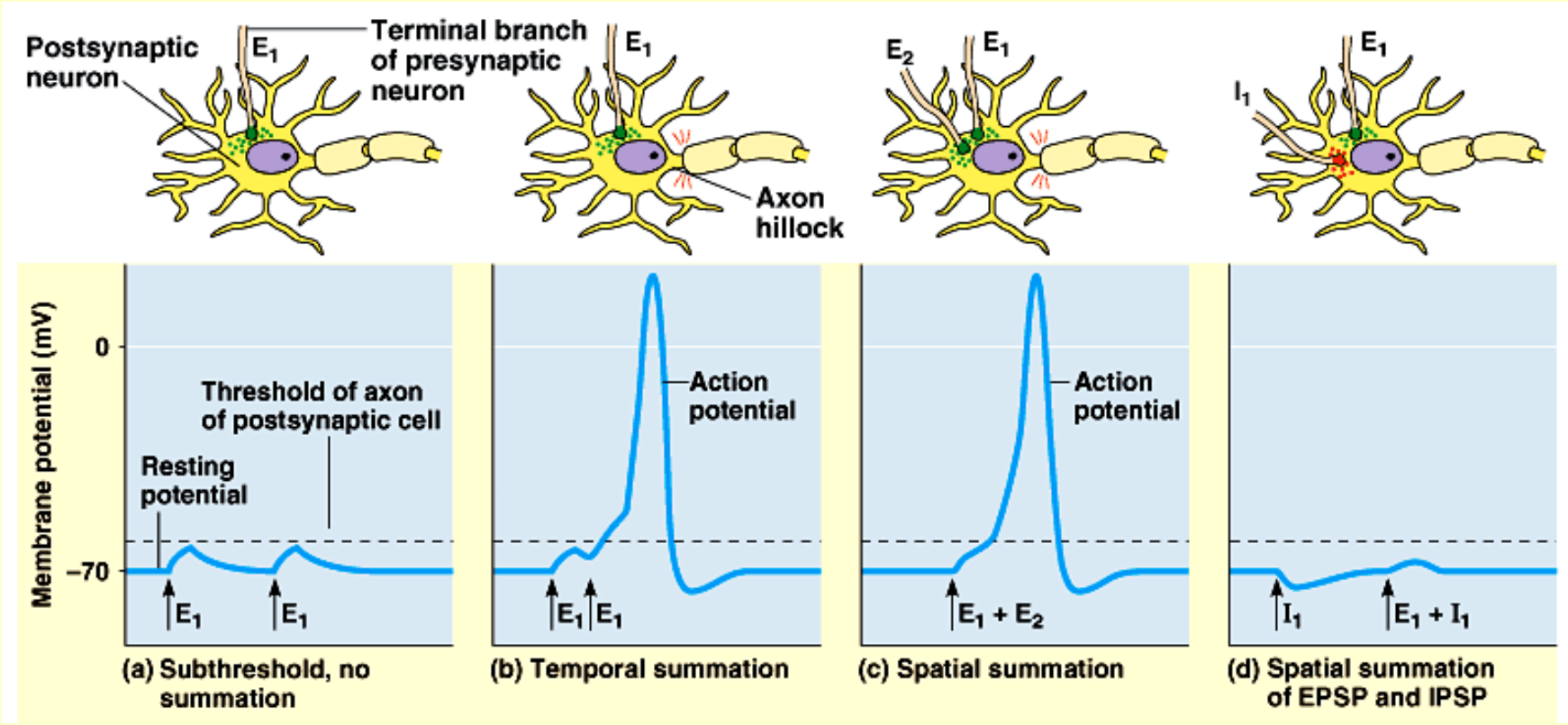


Fig 48.13

How do post-synaptic neurons integrate information from more than one pre-synaptic cell?

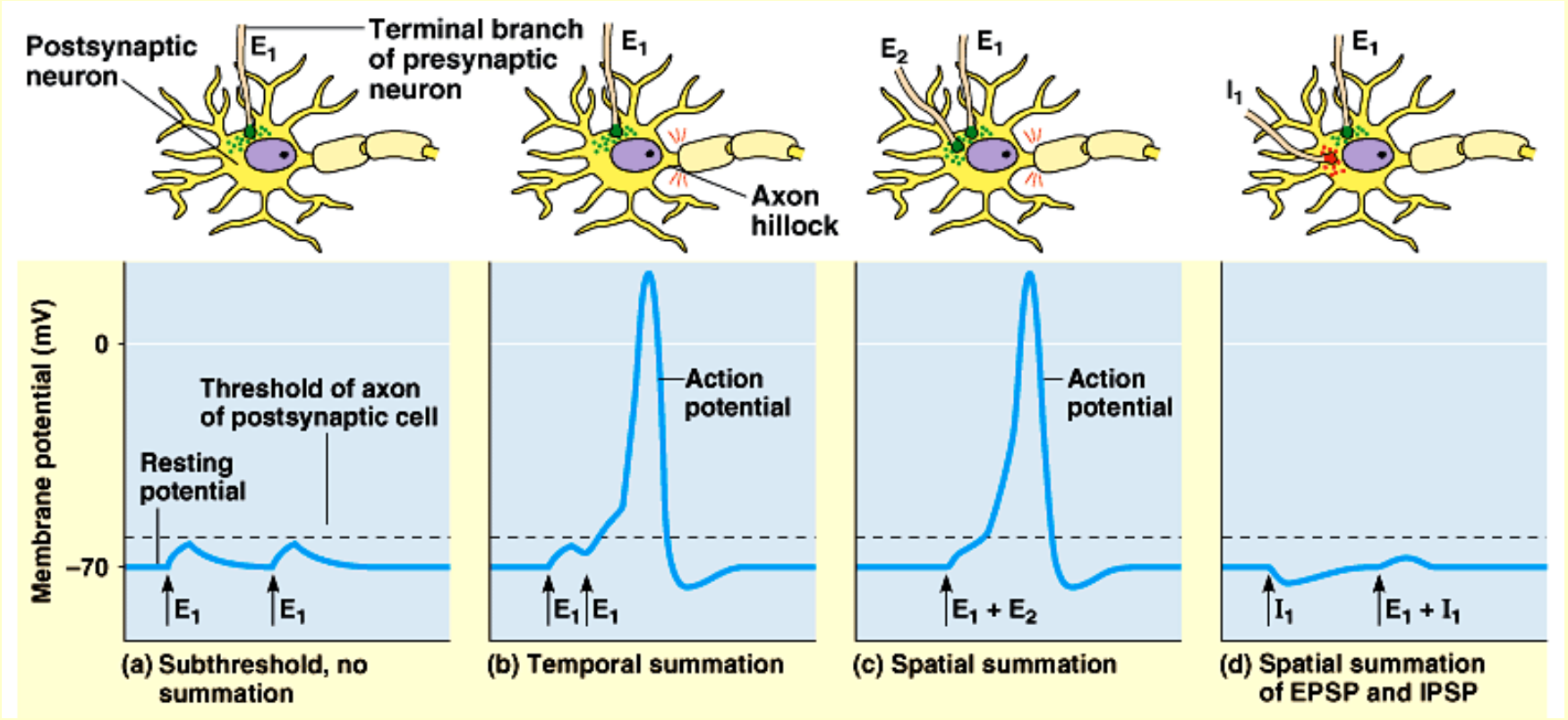
Summation of postsynaptic potentials

- The opening of a ligand-gated channel produces a *post-synaptic potential* – either excitatory (*EPSP*) or inhibitory (*IPSP*)



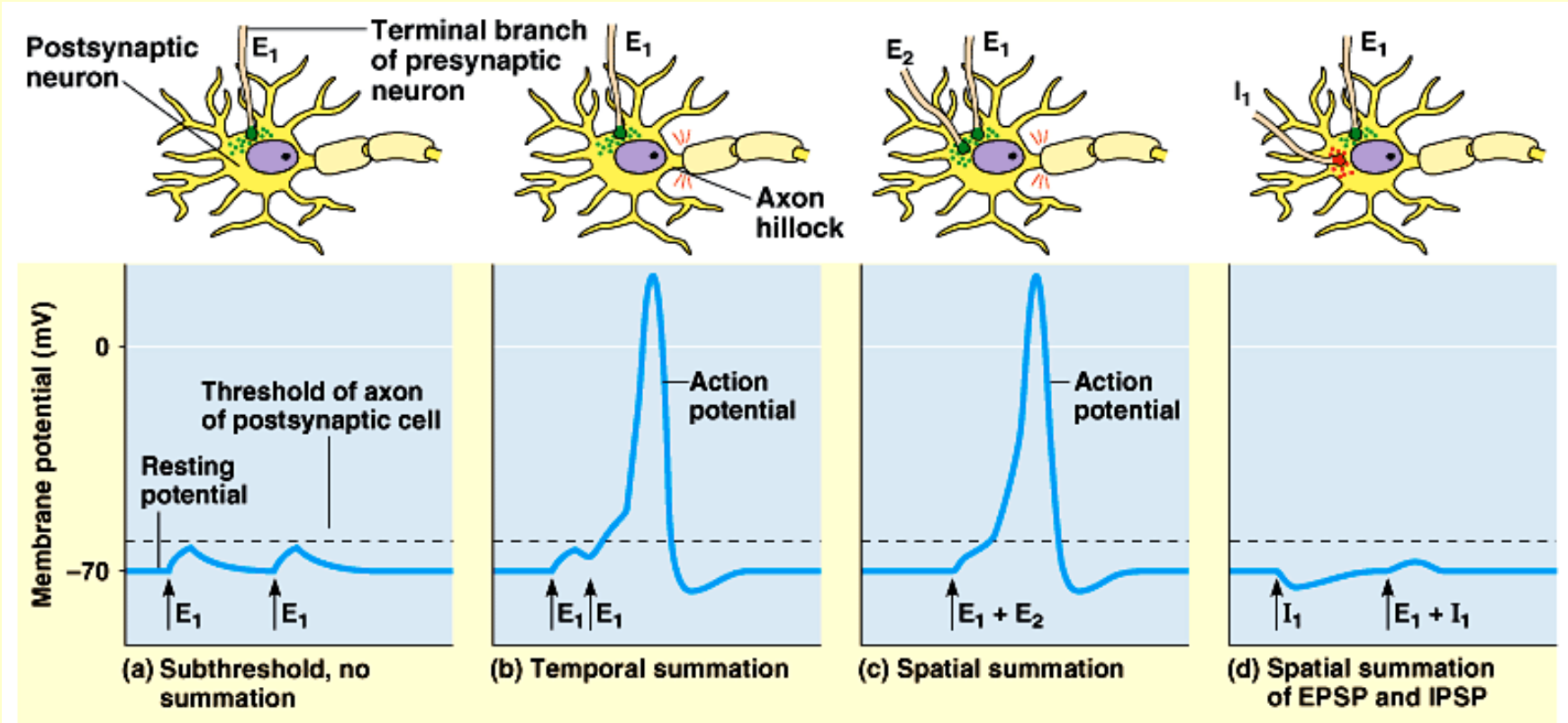
Summation of postsynaptic potentials

- The opening of a ligand-gated channel produces a *post-synaptic potential* – either excitatory (*EPSP*) or inhibitory (*IPSP*)
- If two post-synaptic potentials occur at the same time in different places, or at the same place in rapid succession, their effects add up.



Summation of postsynaptic potentials

- The opening of a ligand-gated channel produces a *post-synaptic potential* – either excitatory (*EPSP*) or inhibitory (*IPSP*)
- If two post-synaptic potentials occur at the same time in different places, or at the same place in rapid succession, their effects add up.
- This adding up is called *spatial* or *temporal* *summation*



- Because voltage spreads along the dendrites and cell body without an action potential, the strength of PSPs decay with distance

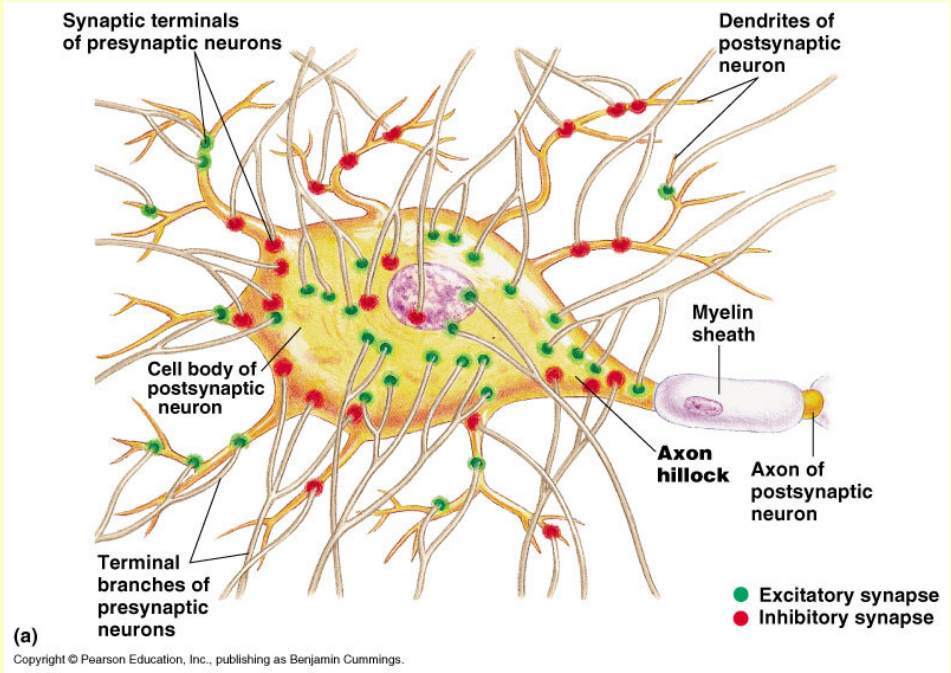


Fig 48.13

- Because voltage spreads along the dendrites and cell body without an action potential, the strength of PSPs decay with distance
- The closer a synapse is to the axon hillock, the stronger its influence on post-synaptic firing.

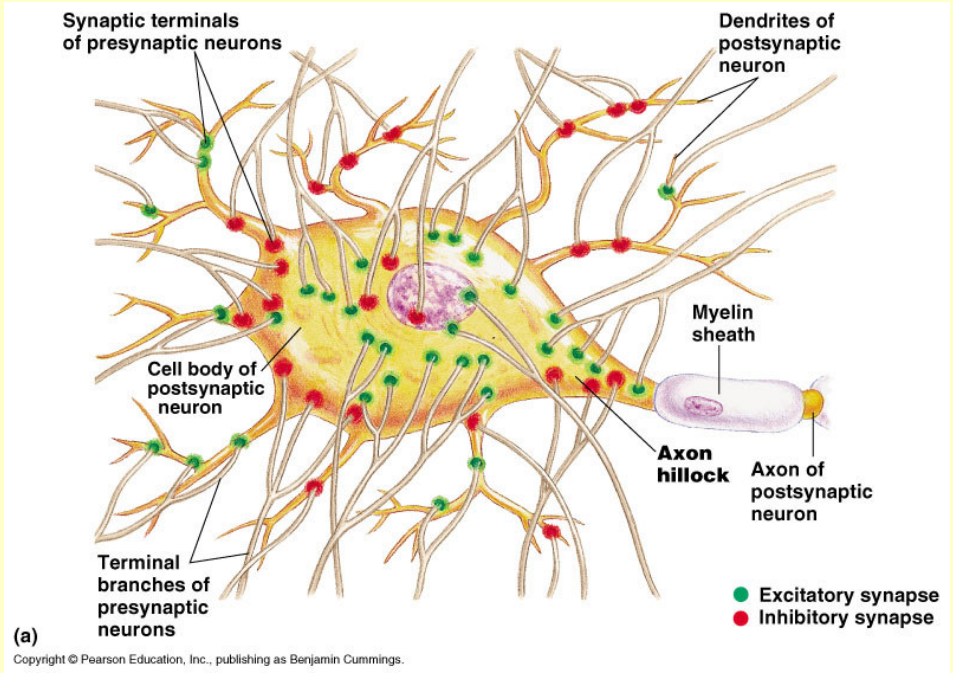


Fig 48.13

The way in which a neuron's EPSPs and IPSPs sum to cause (or prevent) an action potential represents a computation.

Figure 48.19 Embryonic development of the brain