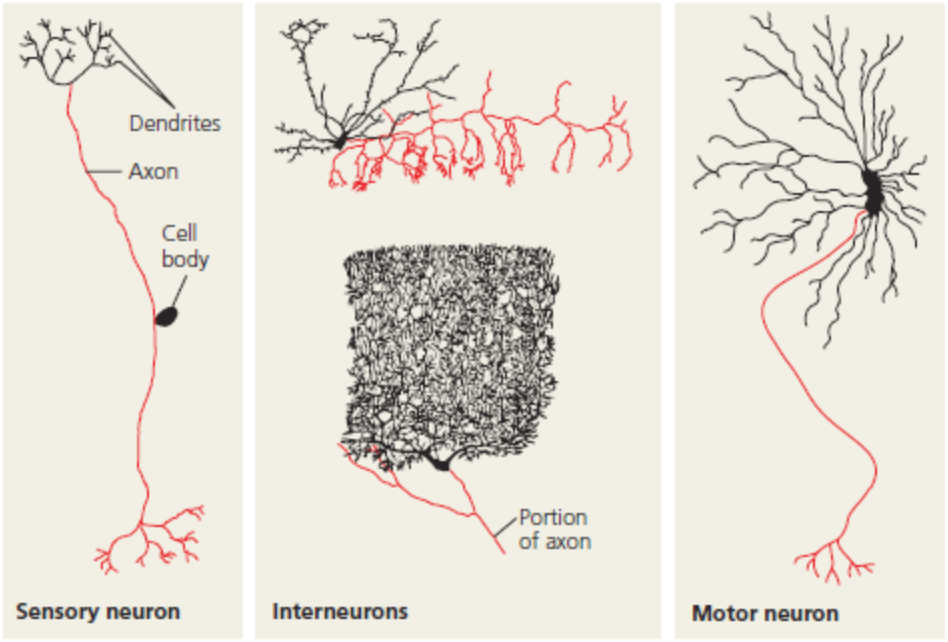
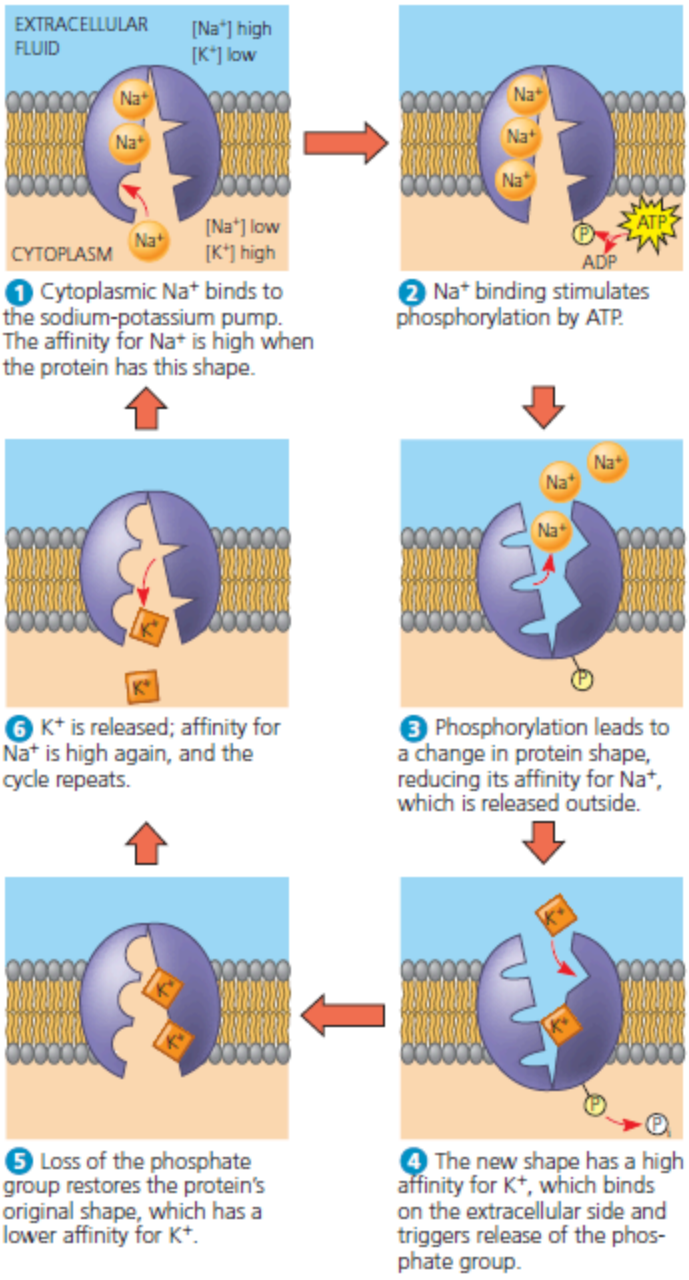
Cheat Sheet



▲ **Figure 48.5 Structural diversity of neurons.** Cell bodies and dendrites are black in these diagrams; axons are red. In the sensory neuron, unlike the other neurons here, the cell body is located partway along the axon that conveys signals from the dendrites to the axon's terminal branches.

Table 48.1 Ion Concentrations Inside and Outside of Mammalian Neurons

Ion	Intracellular Concentration (m*M*)	Extracellular Concentration (m*M*)
Potassium (K^+)	140	5
Sodium (Na^+)	15	150
Chloride (Cl^-)	10	120
Large anions (A^-) inside cell, such as proteins	100	(not applicable)



1 Cytoplasmic Na^+ binds to the sodium-potassium pump. The affinity for Na^+ is high when the protein has this shape.

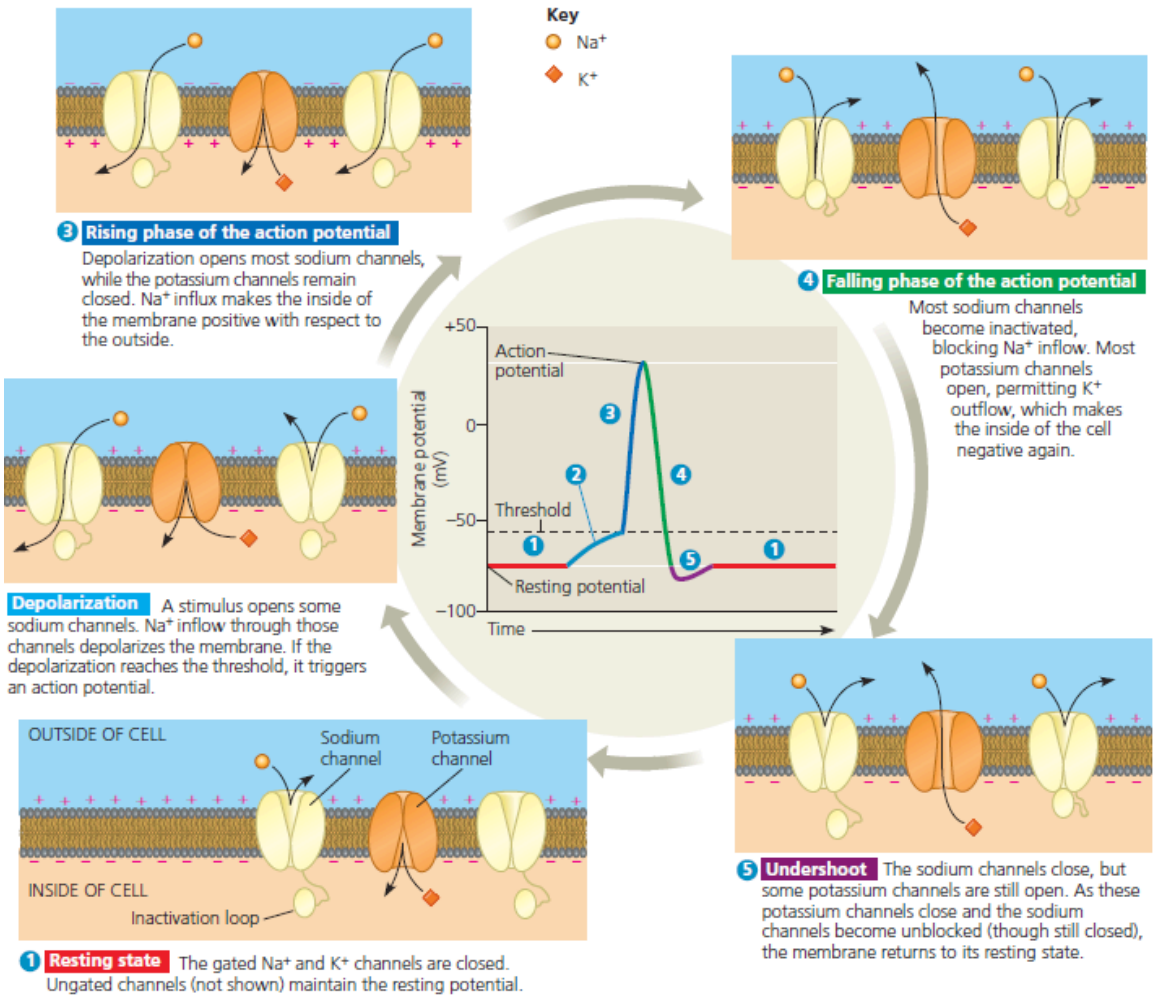
2 Na^+ binding stimulates phosphorylation by ATP.

3 Phosphorylation leads to a change in protein shape, reducing its affinity for Na^+, which is released outside.

4 The new shape has a high affinity for K^+, which binds on the extracellular side and triggers release of the phosphate group.

5 Loss of the phosphate group restores the protein's original shape, which has a lower affinity for K^+.

6 K^+ is released; affinity for Na^+ is high again, and the cycle repeats.



1 Resting state The gated Na^+ and K^+ channels are closed. Ungated channels (not shown) maintain the resting potential.

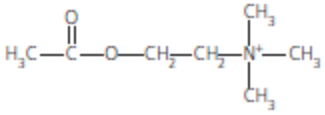
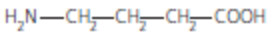
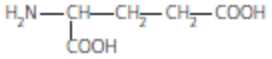
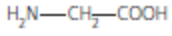
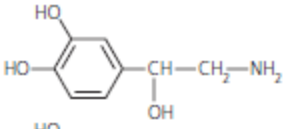
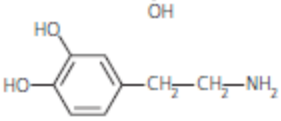
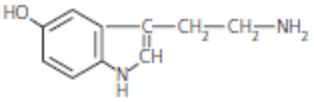
2 Depolarization A stimulus opens some sodium channels. Na^+ inflow through those channels depolarizes the membrane. If the depolarization reaches the threshold, it triggers an action potential.

3 Rising phase of the action potential Depolarization opens most sodium channels, while the potassium channels remain closed. Na^+ influx makes the inside of the membrane positive with respect to the outside.

4 Falling phase of the action potential Most sodium channels become inactivated, blocking Na^+ inflow. Most potassium channels open, permitting K^+ outflow, which makes the inside of the cell negative again.

5 Undershoot The sodium channels close, but some potassium channels are still open. As these potassium channels close and the sodium channels become unblocked (though still closed), the membrane returns to its resting state.

Table 48.2 Major Neurotransmitters

Neurotransmitter	Structure
Acetylcholine	
Amino Acids	
GABA (gamma-aminobutyric acid)	
Glutamate	
Glycine	
Biogenic Amines	
Norepinephrine	
Dopamine	
Serotonin	
Neuropeptides (a very diverse group, only two of which are shown)	
Substance P	Arg—Pro—Lys—Pro—Gln—Gln—Phe—Phe—Gly—Leu—Met
Met-enkephalin (an endorphin)	Tyr—Gly—Gly—Phe—Met
Gases	
Nitric oxide	N=O

Chapter 48 Questions

1. **What are neurons?**
2. **What is *Conus geographus*?**
3. **What is a brain?**
4. **What are ganglia?**
5. **Where are most of a neuron's organelles located?**
6. **What are dendrites?**
7. **What is axon?**
8. **What is a synapse?**
9. **What are neurotransmitters?**
10. **What are the presynaptic and postsynaptic cells?**
11. **What are glial cells (glia)?**
12. **What are the three types of neuron populations?**
13. **What is a central nervous system (CNS)?**
14. **What is the peripheral nervous system (PNS)?**
15. **What are nerves?**
16. **What is membrane potential?**
17. **What is the resting potential?**
18. **Describe the important ion concentrations around mammalian neurons.**
19. **What is the sodium-potassium pump?**
20. **What are ion channels?**
21. **What are leak channels?**
22. **What is an ion's equilibrium potential (E_{ion})**
23. **What is the Nernst equation?**
24. **Why is resting potential closer to E_K than E_{Na}?**
25. **What are gated ion channels?**
26. **What is a voltage-gated ion channel?**
27. **What is a hyperpolarization?**
28. **What is a depolarization?**
29. **What is a graded potential?**
30. **What is an action potential?**
31. **Describe the generation of an action potential.**
32. **What is the refractory period?**
33. **Why do nerve impulses travel in only one direction?**
34. **About how long do action potentials last?**
35. **How is input signal strength conveyed by action potentials?**
36. **What is myotonia?**
37. **What is epilepsy?**
38. **What is the conduction speed/size of giant axons of arthropods/molluscs?**
39. **What is a myelin sheath?**
40. **What are nodes of Ranvier?**

41. **What is saltatory conduction?**
42. **Compare/contrast myelinated axons with giant axons.**
43. **What are electrical synapses?**
44. **What are chemical synapses?**
45. **What is the synaptic cleft?**
46. **What are ligand-gated ion channels?**
47. **What is a postsynaptic potential?**
48. **What is an excitatory postsynaptic potential (EPSP)?**
49. **What is an inhibitory postsynaptic potential (IPSP)?**
50. **What is summation?**
51. **What is temporal summation?**
52. **What is spatial summation?**
53. **How is the synaptic cleft cleared of neurotransmitters?**
54. **How does the nerve gas sarin work?**
55. **What are metabotropic receptors?**
56. **What is acetylcholine?**
57. **What is nicotine?**
58. **What is botulinum toxin?**
59. **Describe the structure of acetylcholine, glutamate, GABA, glycine, norepinephrine, dopamine, serotonin, substance P, met-enkephalin, nitric oxide.**
60. **What is glutamate?**
61. **What role does glycine play in the CNS?**
62. **What is gamma-aminobutyric acid (GABA)?**
63. **What is diazepam?**
64. **What are biogenic amines?**
65. **What is norepinephrine?**
66. **What are dopamine and serotonin?**
67. **What are LSD and mescaline?**
68. **What causes Parkinson's disease?**
69. **How is depression treated?**
70. **What are neuropeptides?**
71. **What is substance P?**
72. **What are endorphins?**
73. **Why are opiates addictive?**
74. **How is NO a special neurotransmitter?**
75. **What role does CO play in the brain?**

Chapter 48 Answers

1. Nerve cells that transfer information within the body
2. Tropical cone snail, injects neurotoxin
3. Large group of organized neurons
4. Simpler clusters of neurons
5. Cell body
6. Highly branched extensions, multiple stud cell body, receive signals with cell body
7. Single per neuron, transmits signals to other cells. Often longer than dendrites, cone-shaped base = axon hillock (where signals are generated), divides into branches at end
8. Junction at each branched end of axon (synaptic terminals)
9. Chemical messengers that pass information from transmitting neuron to receiving cell
10. Transmitting neuron, receiving cell
11. Supporting cells required by vertebrate and most invertebrate neurons. Outnumber neurons in mammalian brain 10-50 fold.
12. Sensory neurons - Transmit information about external stimuli or internal conditions
    Interneurons - form circuits connecting neurons in brain/ganglia, responsible for integration (analysis/interpretation)
    Motor neurons - transmit signals to muscle cells, cause contractions. Others trigger gland activity
    See picture
13. Neurons that carry out integration
14. Neurons that carry information into and out of the CNS
15. Bundles of axons
16. Charge difference (voltage) across plasma membrane
17. Membrane potential of resting neuron, between -60 and -80 mV
18. See picture
19. Uses ATP hydrolysis to transport Na^+ out of cell and K^+ into cell (3 Na^+ for 2 K^+), see pic
20. Pores formed by clusters of specialized proteins that span the membrane, responsible for resting potential since are selectively permeable
21. Channels that are always open (such as potassium channels)
22. Magnitude of membrane voltage at equilibrium for particular ion
23. For ion of net charge 1+, is E_{ion} = 62 mV (log ($[ion]_{outside}/[ion]_{inside}$)), at 37° C
24. E_k=-90, E_{Na}=62 mV, more open potassium ion channels
25. Ion channels that open/close in response to stimuli
26. Channel that opens/closes in response to shift in voltage across plasma membrane
27. Increase in the magnitude of membrane potential from opening of gated K^+ channels, membrane potential more negative
28. Reduction in magnitude of membrane potential, often involves gated sodium channels
29. Shift in membrane potential, has magnitude that varies with strength of stimulus; larger stimulus = greater change in membrane potential, decay with time/distance

30. Massive change in membrane voltage, results from depolarization that shifts membrane potential sufficiently, constant magnitude and can regenerate
31. Depolarization increases membrane potential to threshold, voltage-gated sodium channels open, results in further depolarization, results in more sodium channels opening. Remain open, become inactivated by portion called inactivation loop that blocks ion flow. Sodium channels remain inactivated until membrane returns to resting potential. Potassium channels open more slowly, remain functional until end of potential. see picture
32. Time when second actional potential can't be initiated (during falling and early part of undershoot, sodium channels remain inactivated)
33. Refractory period prevents backpropagation
34. Less than 2 msec
35. Rate at which they fire
36. Periodic spasming of muscles, can be caused by mutations affecting voltage-gated sodium channels in muscles
37. Mutations affecting sodium channels in brain, groups of nerve cells fire simultaneously and excessively, causing seizures
38. 30 m/sec, up to 1 mm wide
39. Electrical insulation that surrounds vertebrate axons, produced by glia (oligodendrocytes in CNS, Schwann cells in PNS, wrap axons in many layers of membrane (mostly lipid))
40. Gaps in myelin sheath to which voltage-gated sodium channels are restricted.
41. Propagating action potentials along myelinated axons
42. 20 μm diameter myelinated axon faster than giant axon with diameter 40x greater, 2000 could be fit in same space as giant axon
43. Contain gap junctions that allow electrical current to flow directly from one neuron to another (synchronize neurons that direct rapid, unvarying behaviors such as squid/lobster escape and vertebrate heart and brain)
44. Rely of release of chemical neurotransmitter by presynaptic neuron to transfer info to target cell, at rest neurotransmitter synthesized at synaptic terminals and packaged in synaptic vesicles. Action potential depolarizes synaptic terminal, opening voltage-gated Ca^{2+} channels, concentration in terminal rises, causes vesicles to fuse with membrane
45. Gap that separates the presynaptic neuron from the postsynaptic cell, less than 50 nm across
46. Ionotropic receptors, often bind and respond to neurotransmitters, clustered in membrane of postsynaptic cell
47. Graded potential in postsynaptic cell
48. Depolarization of postsynaptic membrane, when channels permeable to K^+ and Na^+
49. Moves the membrane potential further from threshold, when channels permeable to only K^+ or Cl^-
50. When individual postsynaptic potentials combine to produce larger postsynaptic potential
51. Two EPSPs occur at single synapse in rapid succession
52. Summation of multiple synapses

53. Some inactivated by enzymatic hydrolysis, others recaptured by presynaptic then repackaged or transferred to glia for recycling/metabolism
54. Triggers paralysis and death because inhibits enzyme that breaks down neurotransmitter controlling skeletal muscles
55. GPCRs at synapses that activate signal transduction pathways involving second messenger in response to neurotransmitter (slower onset, longer lasting)
56. Common neurotransmitter, vital for nervous system functions, including muscle stimulation/memory formation/ learning. At neuromuscular junction, binds to ligand-gated ion channel that opens to produce EPSP, activity terminated by acetylcholinesterase. metabotropic receptor GPCR found in vertebrate CNS and heart, in heart released by neurons to activate STP inhibiting adenylyl cyclase and opening potassium channels to reduce heart pumping rate
57. Chemical found in tobacco and tobacco smoke, acts as stimulant by binding to ionotropic acetylcholine receptor in CNS.
58. Inhibits presynaptic release of acetylcholine, resulting in form of food poisoning (botulism)
59. See picture
60. Neurotransmitter at neuromuscular junction in invertebrates (amino acid), most common neurotransmitter in vertebrate brain, key in formation of long term memory, excitatory
61. Inhibitory amino acid, in parts of CNS outside brain, inhibited by strychnine
62. Amino acid in brain, neurotransmitter at most inhibitory synapses in brain. Increases permeability of postsynaptic membrane to Cl^-
63. Brand name Valium, reduces anxiety by binding to site on GABA receptor
64. Neurotransmitters synthesized from amino acids.
65. biogenic amine from tyrosine, excitatory in autonomic nervous system (branch of PNS).
66. Biogenic amines (first tyrosine, second tryptophan), released at many sites in brain, affect sleep, mood, attention, learning.
67. Psychoactive drugs that produce hallucinatory effects by binding brain receptors for dopamine/serotonin
68. Degenerative illness, associated with lack of dopamine in brain
69. Drugs that increase brain concentrations of biogenic amines (Prozac enhances effect of serotonin by inhibiting reuptake)
70. Relatively short chains of amino acids, operate via GPCRs, typically produced by cleavage of larger protein precursors
71. Key excitatory neurotransmitter that mediates perception of pain
72. Natural analgesics, decrease pain perception, produced in brain during times of physical/emotional stress. Reduce urine output, decrease respiration, produce euphoria, neuropeptides
73. Mimic endorphins (e.g. morphine and heroin)
74. Not stored in cytoplasmic vesicles, synthesized on demand then diffuses into neighboring target cells, produces change, then is broken down, often works like hormone
75. Produced in small amounts, regulates release of hormones from hypothalamus.