Chapter 1: Principles of Signaling and Organization

Test Bank

Type: multiple choice question
Title: Chapter 01 Question 01
1. Which scientist defined the neuron as the single cell unit of the nervous system?
Feedback: *Subhead:* Organization of the vertebrate retina
Learning Objective: Give three examples of how the retina illustrates fundamental mechanisms that operate throughout the nervous system.
Bloom's Level: 1. Remembering
a. Camillo Golgi
b. Otto Loewi
*c. Ramón y Cajal
d Alan Hodgkin
e. Rudolf Virchow

Type: multiple choice question
Title: Chapter 01 Question 02
2. The neuronal connections in the nervous system can be
Feedback: *Subhead:* Organization of the vertebrate retina
Learning Objective: Give three examples of how the retina illustrates fundamental mechanisms that operate throughout the nervous system.
Bloom's Level: 1. Remembering
a. convergent only.
b. divergent only.
c. convergent and divergent only.
d. recurrent only.
*e. convergent, divergent, recurrent, or parallel.

Type: multiple choice question
Title: Chapter 01 Question 03
3. Rods and cones are present in the retina layer that is
Feedback: *Subhead:* Organization of the vertebrate retina
Learning Objective: Name the five nerve cell types in the retina and describe how they are arranged.
Bloom's Level: 3. Applying
a. closest to the lens.
*b. furthest away from the lens.
c. exactly in the middle of the retina.
d. not present in the retina.
e. in different layers in the retina.

Type: multiple choice question
Title: Chapter 01 Question 04
4. In what order is visual information in the retina transmitted?
Feedback: *Subhead:* Organization of the vertebrate retina
Learning Objective: Name the five nerve cell types in the retina and describe how they are arranged.
Bloom's Level: 1. Remembering
a. Bipolar cell→photoreceptor→retinal ganglion cell
b. Retinal ganglion cell→bipolar cell→photoreceptor
*c. Photoreceptor→bipolar cell→retinal ganglion cell
d. Bipolar cell→retinal ganglion cell→photoreceptor
e. Photoreceptor→retinal ganglion cell→bipolar cell

Type: multiple choice question
Title: Chapter 01 Question 05
5. Which of the following cells is not a glial cell?
Feedback: *Subhead:* Organization of the vertebrate retina
Learning Objective: Name the five nerve cell types in the retina and describe how they are arranged.
Bloom's Level: 1. Remembering
a. Schwann cell
*b. Purkinje cell
c. Astrocyte
d. Oligodendrocyte
e. Müller cell

Type: multiple choice question
Title: Chapter 01 Question 06
6. Which of the features below distinguishes neurons from glial cells?
Feedback: *Subhead:* Organization of the vertebrate retina
Learning Objective: Name the five nerve cell types in the retina and describe how they are arranged.
Bloom's Level: 4. Analyzing
*a. Ability of producing action potentials
b. Resting membrane potential
c. Ion channels
d. Receptors for neurotransmitters
e. Ion pumps

Type: multiple choice question
Title: Chapter 01 Question 07
7. The cell type that detects light in the retina is a(n)
Feedback: *Subhead:* Organization of the vertebrate retina
Learning Objective: Name the five nerve cell types in the retina and describe how they are arranged.
Bloom's Level: 1. Remembering
*a. photoreceptor cell.
b. bipolar cell.
c. amacrine cell.
d. Müller cell.
e. ganglion cell.

Type: multiple choice question
Title: Chapter 01 Question 08
8. Which cell connects the photoreceptor cell with the retinal ganglion cell in the retina?
Feedback: *Subhead:* Organization of the vertebrate retina
Learning Objective: Name the five nerve cell types in the retina and describe how they are arranged.
Bloom's Level: 2. Understanding
a. Amacrine cell
b. Müller cell
c. Horizontal cell
*d. Bipolar cell
e. Cone cell

Type: multiple choice question
Title: Chapter 01 Question 09
9. Which cell type has the most elaborate dendritic branching?
Feedback: *Subhead:* Organization of the vertebrate retina
Learning Objective: Name three morphological features that characterize most neurons.
Bloom's Level: 1. Remembering
a. Dorsal root ganglion neuron

b. Motor neuron
c. Pyramidal cell of cortex
d. Retinal ganglion cell
*e. Purkinje cell of cerebellum

Type: multiple choice question
Title: Chapter 01 Question 10
10. Most neurons receive synaptic input in the
Feedback: *Subhead:* Organization of the vertebrate retina
Learning Objective: Name three morphological features that characterize most neurons.
Bloom's Level: 3. Applying
*a. cell body and dendrites.
b. cell body only.
c. axon.
d. dendrites only.
e. axon and dendrites.

Type: multiple choice question
Title: Chapter 01 Question 11
11. The signal intensity is encoded by which property of the action potential?
Feedback: *Subhead:* Signaling in Nerve Cells
Learning Objective: Describe the two types of electrical signals used by neurons.
Bloom's Level: 3. Applying
a. Amplitude
b. Duration
c. Delay time
*d. Frequency
e. Number

Type: multiple choice question
Title: Chapter 01 Question 12
12. Local graded potentials encode the intensity of a signal by
Feedback: *Subhead:* Signaling in Nerve Cells
Learning Objective: Describe the two types of electrical signals used by neurons.
Bloom's Level: 3. Applying
a. delay time.
b. frequency.
*c. size of the membrane potential change.
d. number of potentials.
e. duration.

Type: multiple choice question
Title: Chapter 01 Question 13
13. The resting membrane potential of neurons is typically at
Feedback: *Subhead:* Signaling in Nerve Cells
Learning Objective: Describe the two types of electrical signals used by neurons.
Bloom's Level: 1. Remembering
*a. -65 mV.
b. +65 mV.
c. -6 mV.
d. +6 mV.
e. -650 mV.

Type: multiple choice question
Title: Chapter 01 Question 14

14. The amplitude of the local graded potential is decreasing as the potential is spreading over the neuronal membrane because of the
Feedback: *Subhead:* Signaling in Nerve Cells
Learning Objective: Describe the two types of electrical signals used by neurons.
Bloom's Level: 2. Understanding
a. phospholipid bilayer.
b. presence of myelin sheaths.
c. presence of ion pumps in the plasma membrane.
*d. presence of ion channels in the plasma membrane.
e. net negative charge inside the cell.

Type: multiple choice question
Title: Chapter 01 Question 15
15. Which of the following cells can produce an action potential?
Feedback: *Subhead:* Signaling in Nerve Cells
Learning Objective: Describe the two types of electrical signals used by neurons.
Bloom's Level: 1. Remembering
*a. Retinal ganglion cell
b. Rod photoreceptor
c. Bipolar cell
d. Cone photoreceptor
e. Müller cell

Type: multiple choice question
Title: Chapter 01 Question 16
16. The maximal firing frequency of neurons is
Feedback: *Subhead:* Signaling in Nerve Cells
Learning Objective: Describe the two types of electrical signals used by neurons.
Bloom's Level: 3. Applying
a. 10,000 Hertz.
*b. 1,000 Hertz.
c. 100 Hertz.
d. 10 Hertz.
e. 1 Hertz.

Type: multiple choice question
Title: Chapter 01 Question 17
17. What determines whether the threshold for the initiation of an action potential is reached?
Feedback: *Subhead:* Signaling in Nerve Cells
Learning Objective: Describe the two types of electrical signals used by neurons.
Bloom's Level: 2. Understanding
*a. Combined excitatory and inhibitory inputs
b. Excitatory inputs only
c. Inhibitory inputs only
d. Resting membrane potential
e. The number of synaptic inputs

Type: multiple choice question
Title: Chapter 01 Question 18
18. This technique allows measuring currents through single ion channels.
Feedback: *Subhead:* Signaling in Nerve Cells
Learning Objective: List five key techniques for recording neuronal activity.
Bloom's Level: 1. Remembering
a. Tungsten wire
b. Intracellular recording

*c. Patch recording
d. Multi-electrode recording
e. Extracellular recording.

Type: multiple choice question
Title: Chapter 01 Question 19
19. When using fluorescent probes to visualize neuronal activity, the probe typically detect which ion?
Feedback: *Subhead:* Signaling in Nerve Cells
Learning Objective: List five key techniques for recording neuronal activity.
Bloom's Level: 1. Remembering
a. Na^+
b. K^+
c. Cl^-
d. Mg^{2+}
*e. Ca^{2+}

Type: multiple choice question
Title: Chapter 01 Question 20
20. Which technique is used to measure activity in specific regions of a human brain while the subject is performing a task?
Feedback: *Subhead:* Signaling in Nerve Cells
Learning Objective: List five key techniques for recording neuronal activity.
Bloom's Level: 1. Remembering
a. Multiphoton microscopy
*b. Functional magnetic resonance imaging
c. Electroretinogram
d. Electroencephalogram
e. X-ray

Type: multiple choice question
Title: Chapter 01 Question 21
21. Excitatory postsynaptic potentials are caused by
Feedback: *Subhead:* Signaling in Nerve Cells
Learning Objective: Explain how information is transmitted from neuron to neuron at synapses.
Bloom's Level: 2. Understanding
a. light.
b. hyperpolarization.
*c. depolarization.
d. no change in membrane potential.
e. potassium influx.

Type: multiple choice question
Title: Chapter 01 Question 22
22. The maximum number of synaptic inputs a CNS neuron can have is
Feedback: *Subhead:* Signaling in Nerve Cells
Learning Objective: Explain how information is transmitted from neuron to neuron at synapses.
Bloom's Level: 1. Remembering
a. 10,000.
*b. over 100,000.
c. 1,000.
d. 100,000.
e. 5,000.

Type: multiple choice question
Title: Chapter 01 Question 23

23. Which of the following molecules cannot be transmitted from one neuron to the next through an electrical synapse?
Feedback: *Subhead:* Signaling in Nerve Cells
Learning Objective: Explain how information is transmitted from neuron to neuron at synapses.
Bloom's Level: 5. Evaluating
a. Sodium ion
b. Chloride ion
c. cAMP
d. Glucose
*e. Protein kinase A

Type: multiple choice question
Title: Chapter 01 Question 24
24. Which of these properties describes the electrical synapse best?
Feedback: *Subhead:* Signaling in Nerve Cells
Learning Objective: Explain how information is transmitted from neuron to neuron at synapses.
Bloom's Level: 2. Understanding
a. Ion-specific
*b. Size-specific
c. Slow conduction
d. Only occurs between neurons
e. Only occurs between glial cells

Type: multiple choice question
Title: Chapter 01 Question 25
25. The amount of neurotransmitter per vesicle is
Feedback: *Subhead:* Signaling in Nerve Cells
Learning Objective: Explain how information is transmitted from neuron to neuron at synapses.
Bloom's Level: 4. Analyzing
a. dependent on the amount of depolarization.
b. dependent on the age of the neuron.
c. dependent on the frequency of the action potential.
*d. relatively constant for a specific neuron.
e. is highly variable.

Type: multiple choice question
Title: Chapter 01 Question 26
26. Which statement describes synaptic plasticity best?
Feedback: *Subhead:* Signaling in Nerve Cells
Learning Objective: Explain how information is transmitted from neuron to neuron at synapses.
Bloom's Level: 5. Evaluating
a. Ability to release different amounts of neurotransmitters
b. Ability to switch between excitatory and inhibitory postsynaptic potentials
*c. Temporary changes in synaptic efficacy
d. Ability to release different types of neurotransmitters
e. Temporary changes in number of synapses

Type: multiple choice question
Title: Chapter 01 Question 27
27. Long-term synaptic plasticity typically involves changes in
Feedback: *Subhead:* Signaling in Nerve Cells
Learning Objective: Explain how information is transmitted from neuron to neuron at synapses.
Bloom's Level: 2. Understanding
*a. gene expression.
b. threshold for action potential.

c. chan membrane resistance.
d. resting membrane potential.
e. shape of the action potential.

Type: multiple choice question
Title: Chapter 01 Question 28
28. Neurotransmitters can be released from
Feedback: *Subhead:* Signaling in Nerve Cells
Learning Objective: Explain how information is transmitted from neuron to neuron at synapses.
Bloom's Level: 2. Understanding
a. presynaptic terminals only.
b. cell bodies only.
*c. cell bodies, axons and dendrites.
d. dendrites only.
e. glial cells only.

Type: multiple choice question
Title: Chapter 01 Question 29
29. Different types of neurons can be distinguished by
Feedback: *Subhead:* Cellular and Molecular Biology of Neurons
Learning Objective: List two roles that calcium plays in the cellular biology of neurons.
Bloom's Level: 1. Remembering
a. sodium/potassium pumps.
*b. neurotransmitters.
c. aquaporins.
d. voltage-gated sodium channels.
e. synaptotagmins.

Type: multiple choice question
Title: Chapter 01 Question 30
30. Which of these proteins is not regulated by calcium?
Feedback: *Learning Objective:* List two roles that calcium plays in the cellular biology of neurons.
Subhead: Cellular and Molecular Biology of Neurons
Bloom's Level: 1. Remembering
a. Calmodulin
b. Protein kinase C
c. Calpain
*d. NCAM
e. Phospholipase C

Type: multiple choice question
Title: Chapter 01 Question 31
31. The intracellular calcium concentration in neurons is
Feedback: *Subhead:* Cellular and Molecular Biology of Neurons
Learning Objective: List two roles that calcium plays in the cellular biology of neurons.
Bloom's Level: 1. Remembering
*a. 0.0001 mM.
b. 0.001 mM.
c. 0.01 mM.
d. 0.1 mM.
e. 1 mM.

Type: multiple choice question
Title: Chapter 01 Question 32
32. Which statement about axonal transport is true?

Feedback: *Subhead:* Cellular and Molecular Biology of Neurons
Learning Objective: Explain why axonal transport is essential to the structure and function of neurons.
Bloom's Level: 5. Evaluating
a. It only occurs in mature neurons.
b. It is unidirectional.
*c. It is bidirectional.
d. It only transports neurotransmitter vesicles.
e. It only transports mitochondria.

Type: multiple choice question
Title: Chapter 01 Question 33
33. Neurons can get very old if they do not get damaged. How does the cell ensure that degraded proteins are replaced by new proteins everywhere in a neuron with many fine extended processes?
Feedback: *Subhead:* Cellular and Molecular Biology of Neurons
Learning Objective: Explain why axonal transport is essential to the structure and function of neurons.
Bloom's Level: 3. Applying
a. By regulation of ubiquitination
*b. By axonal transport
c. By regulation of gene expression
d. By endocytosis
e. By posttranslational modifications

Type: multiple choice question
Title: Chapter 01 Question 34
34. Neural precursor cells have which property?
Feedback: *Subhead:* Signals for Development of the Nervous System
Learning Objective: Explain what cell fate mapping is and how it is used.
Bloom's Level: 1. Remembering
a. They can still divide.
b. They have the potential to give rise to neurons.
c. They have the potential to give rise to glial cells.
d. They derive from neuroectoderm.
*e. All of the above

Type: multiple choice question
Title: Chapter 01 Question 35
35. Which molecular tools have been frequently used to analyze fate mapping in developing embryos?
Feedback: *Subhead:* Signals for Development of the Nervous System
Learning Objective: Explain what cell fate mapping is and how it is used.
Bloom's Level: 1. Remembering
*a. Genetically encoded fluorescent proteins
b. Antibodies
c. In situ hybridization
d. Fluorescent microbeads
e. Optogenetics

Type: multiple choice question
Title: Chapter 01 Question 36
36. The typical order of events during nervous system development is
Feedback: *Subhead:* Signals for Development of the Nervous System
Learning Objective: Explain what cell fate mapping is and how it is used.
Bloom's Level: 1. Remembering
a. cell migration→cell differentiation→axon guidance→cell proliferation.
b. axon guidance→cell migration→cell proliferation→cell differentiation.

c. cell differentiation→cell proliferation→axon guidance→cell migration.
d. cell migration→cell differentiation→cell proliferation→axon guidance.
*e. cell proliferation→cell differentiation→cell migration→axon guidance.

Type: multiple choice question
Title: Chapter 01 Question 37
37. Which model organism has been studied first to investigate how genes control development?
Feedback: *Subhead:* Signals for Development of the Nervous System
Learning Objective: Explain what cell fate mapping is and how it is used.
Bloom's Level: 1. Remembering
a. Mouse
b. *Xenopus*
*c. *Drosophila*
d. Chicken
e. Rat

Type: multiple choice question
Title: Chapter 01 Question 38
38. Which pair of cell types has the same precursor cell?
Feedback: *Subhead:* Signals for Development of the Nervous System
Learning Objective: Explain what cell fate mapping is and how it is used.
Bloom's Level: 1. Remembering
a. Neuron and epithelial cell
b. Glial cell and fibroblast
*c. Neuron and glial cell
d. Neuron and endothelial cell
e. Glial cell and leukocyte

Type: multiple choice question
Title: Chapter 01 Question 39
39. The main molecular signals that control cell differentiation are
Feedback: *Subhead:* Signals for Development of the Nervous System
Learning Objective: Explain what cell fate mapping is and how it is used.
Bloom's Level: 1. Remembering
a. cyclins.
*b. transcription factors and morphogens.
c. morphogens.
d. hormones.
e. transcription factors.

Type: multiple choice question
Title: Chapter 01 Question 40
40. Which neuronal connection in an adult human has the highest regeneration potential following injury?
Feedback: *Subhead:* Regeneration of the Nervous System after Injury
Learning Objective: Identify several animals in which regeneration occurs and several in which it does not occur.
Bloom's Level: 2. Understanding
a. Optic nerve
*b. Sciatic nerve
c. Dorsal column of spinal cord
d. Ventral column of spinal cord
e. Thalamo-cortical connection

Type: essay/short answer question

Title: Chapter 01 Question 41
41. Which modern imaging technique can provide information about the area of the brain that is active when performing a specific task such as watching a video, and what are the limitations of this technique?
Feedback: Functional magnetic resonance (fMRI) imaging can reveal which specific brain area is active while performing a certain task; however, it cannot show which individual neuronal circuits are involved in this function and how signals are transmitted.
Subhead: Organization of the vertebrate retina
Learning Objective: Give three examples of how the retina illustrates fundamental mechanisms that operate throughout the nervous system.
Bloom's Level: 3. Applying

Type: essay/short answer question
Title: Chapter 01 Question 42
42. Retina not only contains neurons but also glial cells. What are some key functions of glial cells and what is the name of the major glial cell type in the retina?
Feedback: Glial cells have major support functions for neurons including myelination, immune function, nutrition, controlling extracellular environment and regulating development. The major glial cell of the retina is the Müller cell.
Subhead: Organization of the vertebrate retina
Learning Objective: Give three examples of how the retina illustrates fundamental mechanisms that operate throughout the nervous system.
Bloom's Level: 1. Remembering

Type: essay/short answer question
Title: Chapter 01 Question 43
43. How is the visual information maintained as signals are sent from the eye to the brain?
Feedback: Visual information like other sensory information is transmitted in a topographic fashion ensuring that spatial information is maintained by the arrangement of retinal ganglion cell axons within the optic nerve and then properly mapped to the visual centers in the brain.
Subhead: Organization of the vertebrate retina
Learning Objective: Give three examples of how the retina illustrates fundamental mechanisms that operate throughout the nervous system.
Bloom's Level: 4. Analyzing

Type: essay/short answer question
Title: Chapter 01 Question 44
44. Do all neurons strictly follow the cellular organization with cell body, axon and dendrites? If not, please provide an example for a neuron that does not follow this basic organization.
Feedback: Whereas most neurons have a cell body, one axon and several dendrites, some neurons do not, e.g. the photoreceptor cell in the retina does not have axon and dendrites.
Subhead: Organization of the vertebrate retina
Learning Objective: Name three morphological features that characterize most neurons.
Bloom's Level: 3. Applying

Type: essay/short answer question
Title: Chapter 01 Question 45
45. What technique can you use to determine the connectivity of neurons in brain circuits?
Feedback: You can inject specific viruses such as Rabies into the nervous system of experimental animals. The virus will be taken up by specific neurons. The virus can be transmitted at synapses to the next neuron. The infected neurons can be visualized by immunofluorescence.
Subhead: Organization of the vertebrate retina
Learning Objective: Name three morphological features that characterize most neurons.
Bloom's Level: 4. Analyzing

Type: essay/short answer question

Title: Chapter 01 Question 46
46. Contrast the properties of local graded potentials and action potentials.
Feedback: Local graded potentials have small and varying amplitudes (0.1-10 mV) and duration (ms to min). They fade quickly and are not suitable for long range transmission. Local graded potentials are stimulated by physical stimuli or chemical transmitters. Action potentials on the other hand have a unique shape that is always the same. They have a larger amplitude (70-100 mV) and shorter duration (1-10 ms) compared to local graded potential. The signal intensity is encoded by the frequency of action potentials. The action potential is actively regenerated, all or none, and suitable for long range transmission.
Subhead: Signaling in Nerve Cells
Learning Objective: Describe the two types of electrical signals used by neurons.
Bloom's Level: 2. Understanding

Type: essay/short answer question
Title: Chapter 01 Question 47
47. The fastest firing frequency of neurons is limited to 1000 Hz. Please explain why neurons cannot generate action potentials at higher frequency.
Feedback: After a neuron fires an action potential, there is a brief period, called the absolute refractory period, during which time it is impossible to make the neuron fire another action potential. This is due to inactivation of sodium channels.
Subhead: Signaling in Nerve Cells
Learning Objective: Describe the two types of electrical signals used by neurons.
Bloom's Level: 2. Understanding

Type: essay/short answer question
Title: Chapter 01 Question 48
48. Intracellular electrodes allow recording of resting membrane, local graded and action potentials; however, recordings are limited to a few minutes. Why can't you typically record for longer time with an intracellular electrode?
Feedback: Because the sharp electrode impales the membrane, the membrane becomes damaged and molecules will leak in and out of the cell in an uncontrolled fashion until the cell dies.
Subhead: Signaling in Nerve Cells
Learning Objective: List five key techniques for recording neuronal activity.
Bloom's Level: 5. Evaluating

Type: essay/short answer question
Title: Chapter 01 Question 49
49. Explain a benefit of chemical transmission between two neurons.
Feedback: Although transmission using a chemical synapse is generally slower than with an electrical synapse, chemical transmission provides more option for complex signaling and integration of signals. Different neurotransmitters can elicit excitatory and inhibitory postsynaptic responses. These different types of responses allow the nervous system to encode more complex signals.
Subhead: Signaling in Nerve Cells
Learning Objective: Explain how information is transmitted from neuron to neuron at synapses.
Bloom's Level: 5. Evaluating

Type: essay/short answer question
Title: Chapter 01 Question 50
50. Explain how channelrhodopsin works.
Feedback: Channelrhodopsin is light-activated ion channel originally found in green algae. It has been adapted as optogenetic tools for neuroscience. By expressing channelrhodopsin in neurons and exciting it with blue light, one can depolarize the neuron with light control.
Subhead: Signaling in Nerve Cells
Learning Objective: Explain how information is transmitted from neuron to neuron at synapses.
Bloom's Level: 2. Understanding

Type: essay/short answer question
Title: Chapter 01 Question 51
51. Explain a main benefit of electrical synapse and provide examples where these synapses play a role.
Feedback: Electrical synapses allow fast electrical signaling between adjacent cells that are electrically coupled. They are especially important where synchronous firing is essential. Electrical synapses occur throughout the central nervous system in vertebrates and invertebrates. Specific examples include the horizontal cells in the retina, heart muscle, ink gland of Aplysia, and Giant synapse in crayfish abdominal nerve.
Subhead: Signaling in Nerve Cells
Learning Objective: Explain how information is transmitted from neuron to neuron at synapses.
Bloom's Level: 3. Applying

Type: essay/short answer question
Title: Chapter 01 Question 52
52. Calcium does not contribute much to the level of the resting membrane potential or action potential; however, it is a key signal for releasing neurotransmitter from the presynaptic terminal. Explain why.
Feedback: In contrast to the other ions, sodium, potassium, and chloride, calcium is present in much lower concentrations but in a steep concentration gradient with 1-2 mM outside the cell and 0.0001 mM intracellularly. Furthermore, the plasma membrane has a low permeability to calcium. For all these reasons, calcium does not affect the resting or action potential level much, but acts as a specific signal for synaptic vesicle release.
Subhead: Cellular and Molecular Biology of Neurons
Learning Objective: List two roles that calcium plays in the cellular biology of neurons.
Bloom's Level: 5. Evaluating

Type: essay/short answer question
Title: Chapter 01 Question 53
53. For a long time there was a dogma in the field that axons and their terminal cannot synthesize proteins. There is a lot of evidence that this is not correct and that local protein translation occurs in axon, growth cones and synapse. Explain why axonal transport is not always sufficient to deliver proteins to the sites where they are needed.
Feedback: Axons can be extremely long compared to the dimensions of the cell body, 100,000 times longer. Axonal transport is not fast enough to deliver specific proteins to axonal terminals within the timeframe of a few minutes; thus, there is a need for local protein synthesis to respond quickly to changes during axon guidance, regeneration, and synaptic plasticity.
Subhead: Cellular and Molecular Biology of Neurons
Learning Objective: Explain why axonal transport is essential to the structure and function of neurons.
Bloom's Level: 4. Analyzing

Type: essay/short answer question
Title: Chapter 01 Question 54
54. The adult human brain contains in average 10^{11} neurons making 10^{14} connections. The human genome has only about 24,000 genes. Even if 1000 genes would encode for axon guidance and synaptic targeting molecules, how is it possible to specify 10^{14} connections with only 10^{3} genes?
Feedback: There is clearly no possible synaptic targeting mechanism with each of the 10^{14} synapses specified with a different protein/gene. Molecules that guide axons and mediate synaptic targeting act in concert on multiple axons together in a spatiotemporally controlled fashion. Axons initially grow together before individual axons split off and innervate specific areas. Furthermore, signaling states, regulation of receptor expression, and receptor interactions provide additional levels of modulation to achieve specificity and complexity.
Subhead: Signals for Development of the Nervous System
Learning Objective: Explain what cell fate mapping is and how it is used.
Bloom's Level: 5. Evaluating

Type: essay/short answer question

Title: Chapter 01 Question 55
55. The adult mammalian central nervous system has very limited regeneration capability. This is one of the major challenges in the field of neuronal repair and regeneration. Can you provide some possible explanations for this limited regeneration potential?
Feedback: Different possible explanations have been develop to address this questions. One explanation is the lack of growth promoting factors in the adult mammalian CNS. Another one is the presence of inhibitory molecules such as proteosulfate glycan or Nogo. Thirdly, the formation of astroglial scar has been cited as potential reason that prevents the regrowth of axons.
Subhead: Regeneration of the Nervous System after Injury
Learning Objective: Identify several animals in which regeneration occurs and several in which it does not occur.
Bloom's Level: 4. Analyzing