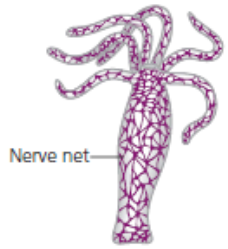
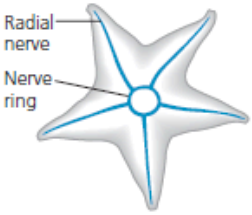
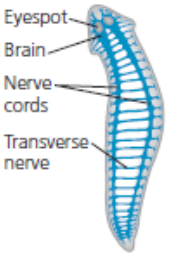
Cheat Sheet



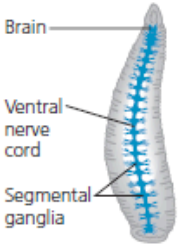
(a) Hydra (cnidarian)



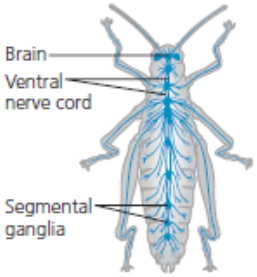
(b) Sea star (echinoderm)



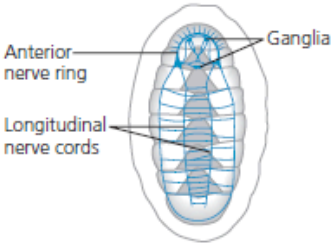
(c) Planarian (flatworm)



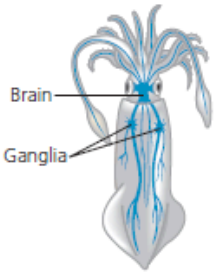
(d) Leech (annelid)



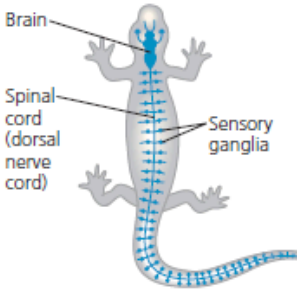
(e) Insect (arthropod)



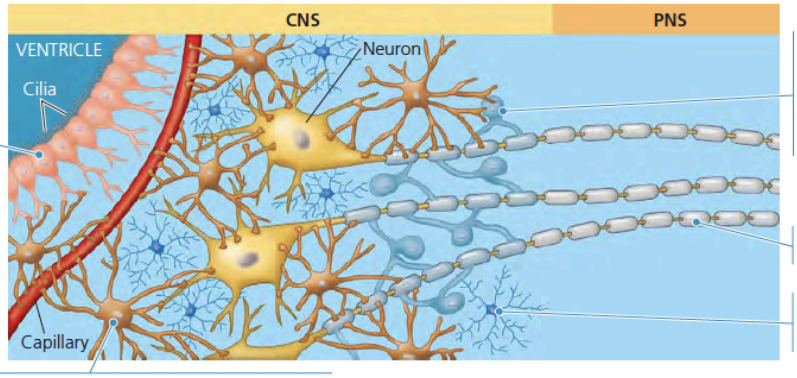
(f) Chiton (mollusc)



(g) Squid (mollusc)



(h) Salamander (vertebrate)



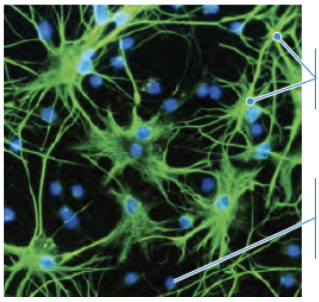
Ependymal cells line the ventricles and have cilia that promote circulation of the cerebrospinal fluid.

Oligodendrocytes myelinate axons in the CNS. Myelination greatly increases the conduction speed of action potentials.

Schwann cells myelinate axons in the PNS.

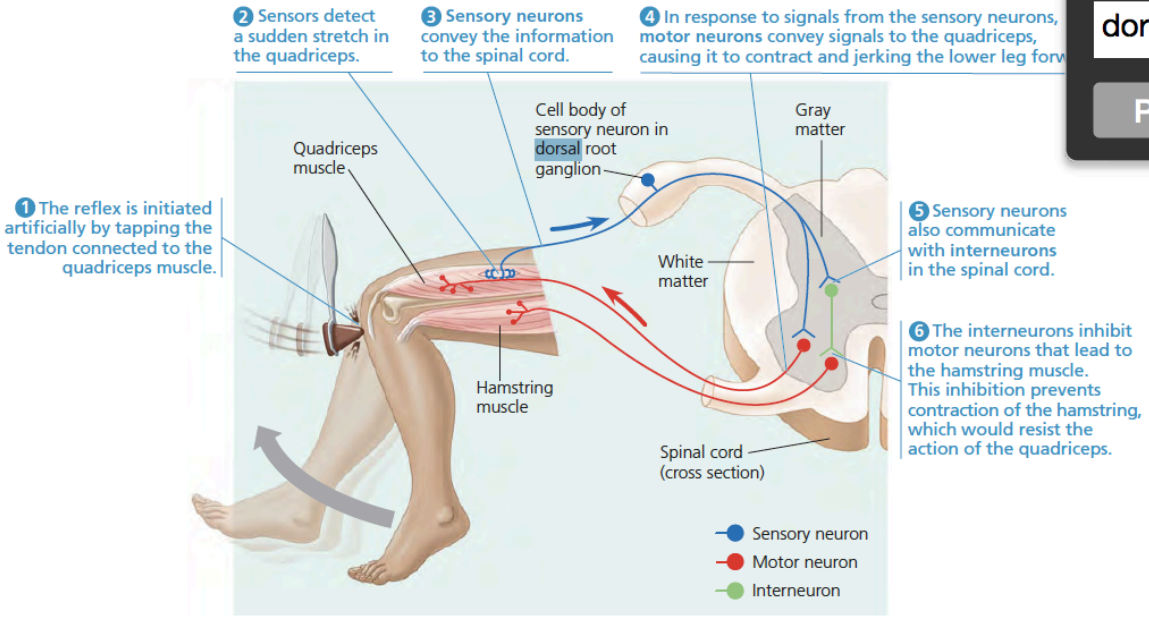
Microglia are immune cells that protect against pathogens.

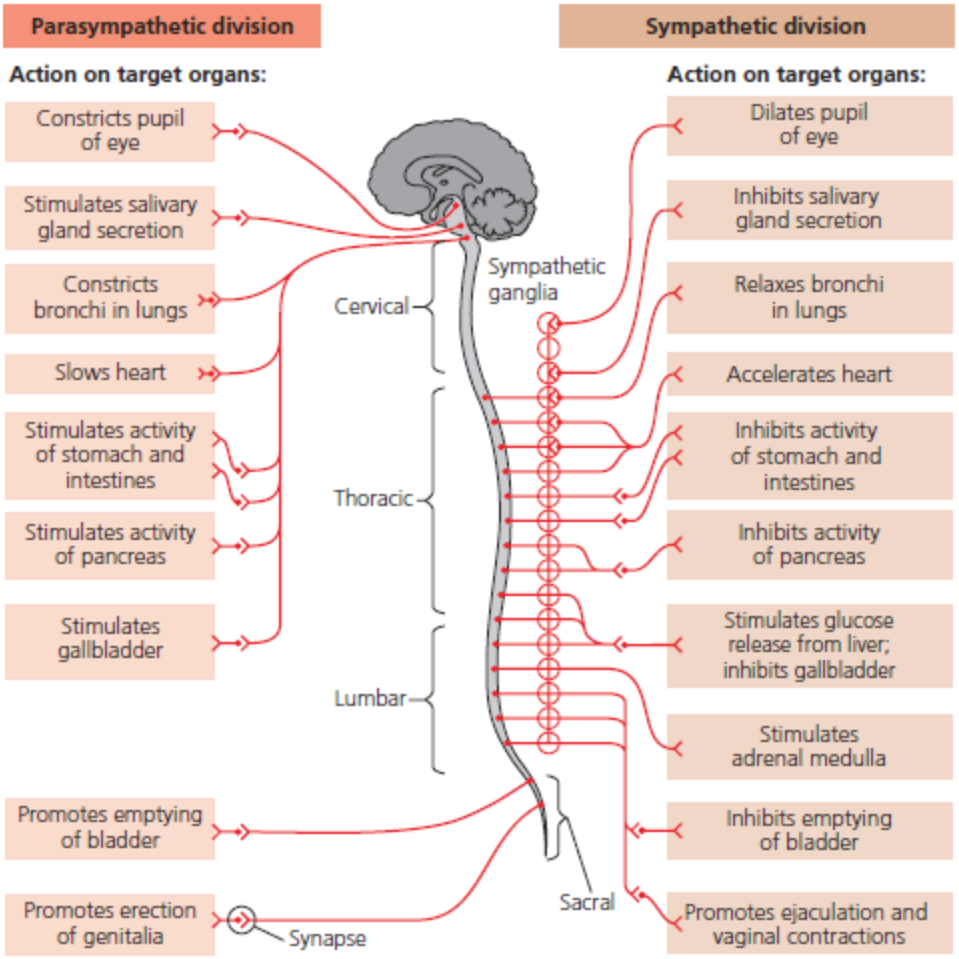
Astrocytes (from the Greek *astron*, star) facilitate information transfer at synapses and in some instances release neurotransmitters. Astrocytes next to active neurons cause nearby blood vessels to dilate, increasing blood flow and enabling the neurons to obtain oxygen and glucose more quickly. Astrocytes also regulate extracellular concentrations of ions and neurotransmitters.

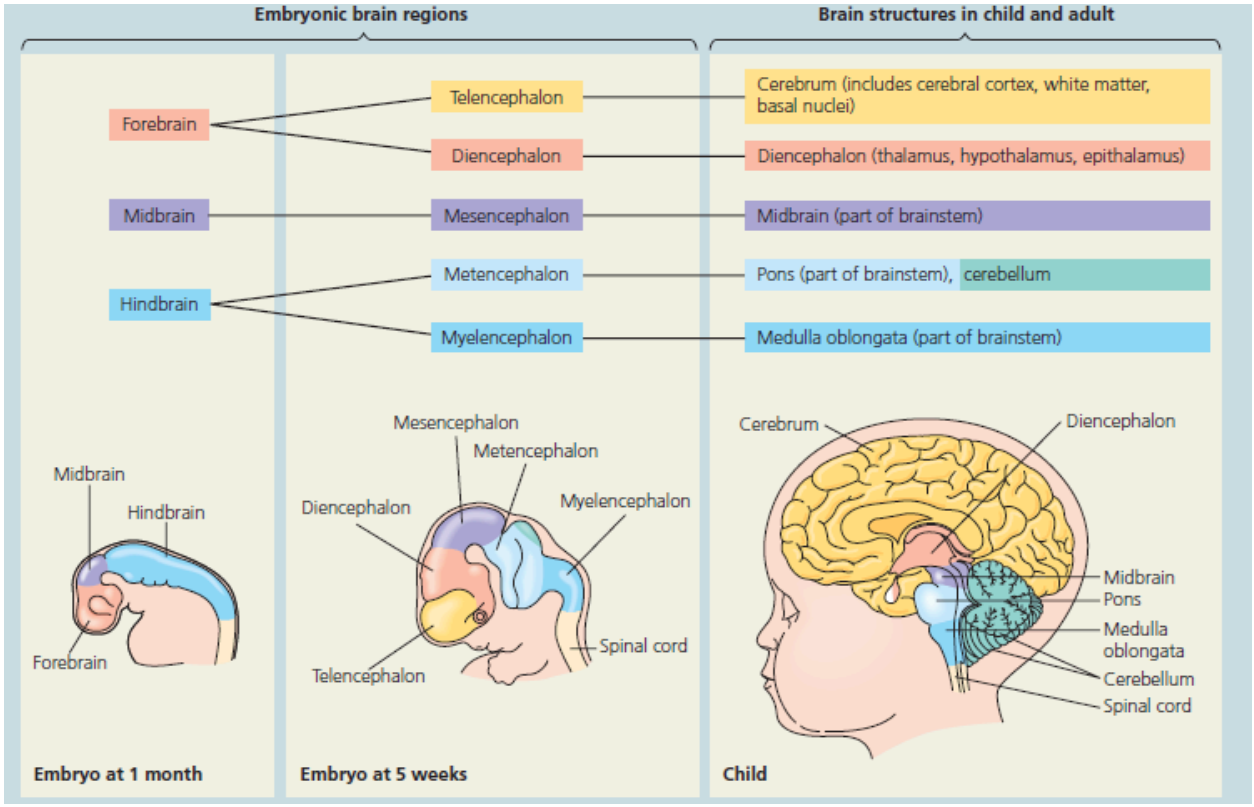


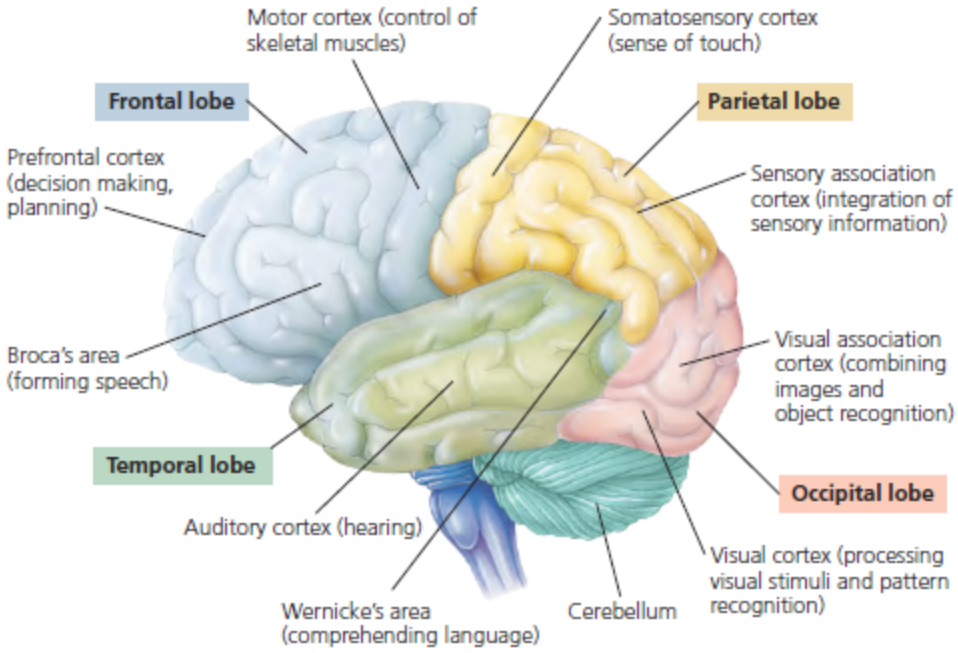
The green cells in this mammalian brain tissue are astrocytes labeled with a fluorescent antibody.

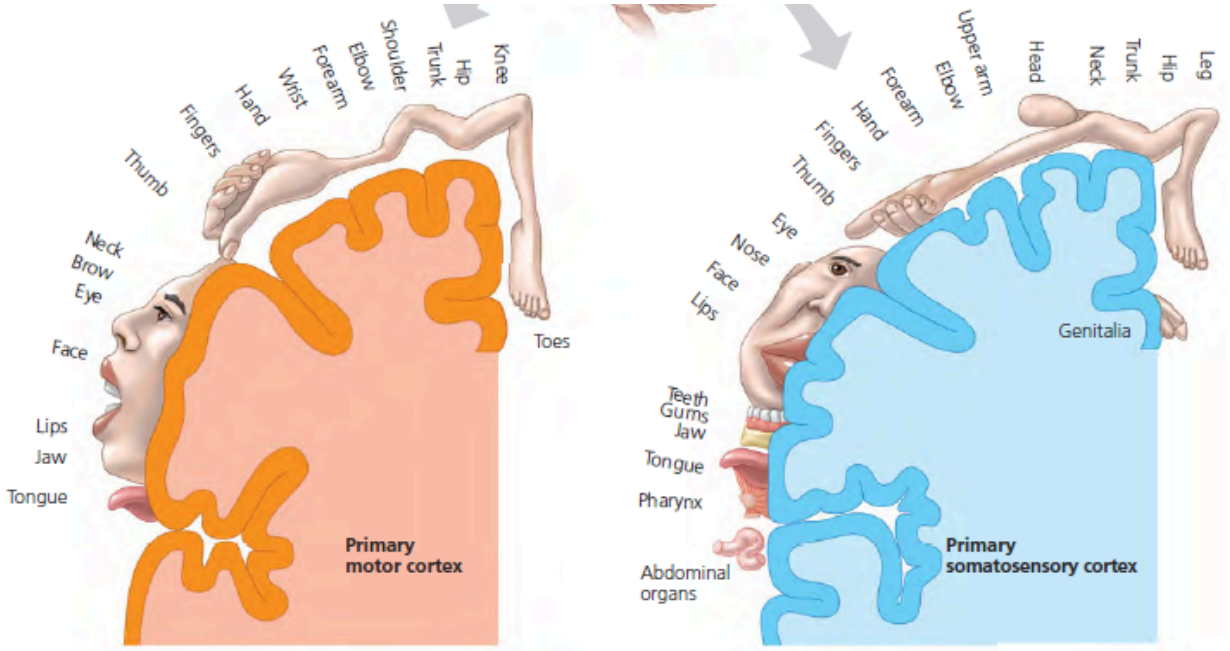
A blue dye that binds DNA in the nuclei of all cells reveals the intermingling of astrocytes with other cells, predominantly neurons.

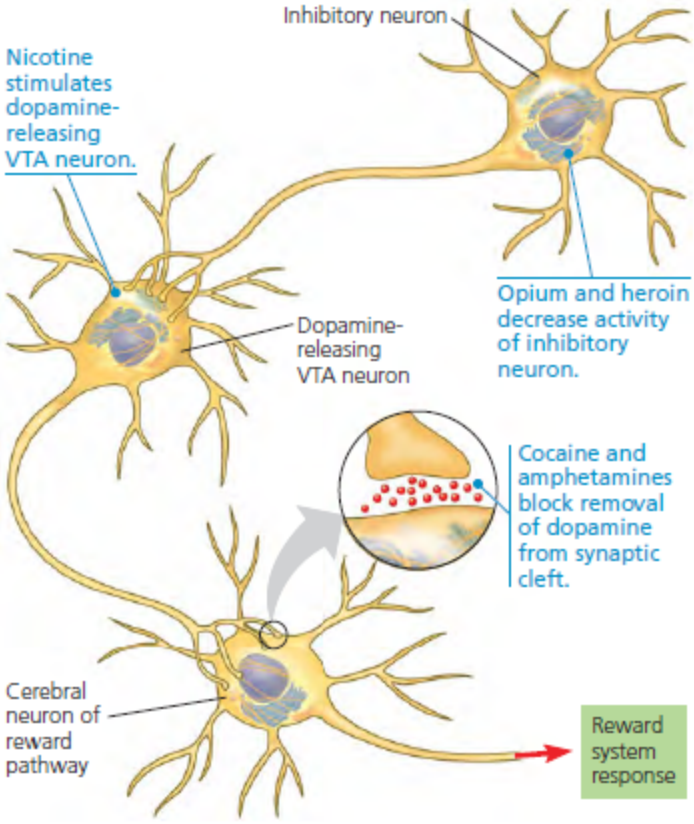





Embryonic brain regions
Brain structures in child and adult
Forebrain
Midbrain
Hindbrain
Telencephalon
Diencephalon
Mesencephalon
Metencephalon
Myelencephalon
Cerebrum (includes cerebral cortex, white matter, basal nuclei)
Diencephalon (thalamus, hypothalamus, epithalamus)
Midbrain (part of brainstem)
Pons (part of brainstem), cerebellum
Medulla oblongata (part of brainstem)
Midbrain
Hindbrain
Forebrain
Mesencephalon
Metencephalon
Diencephalon
Myelencephalon
Spinal cord
Telencephalon
Cerebrum
Diencephalon
Midbrain
Pons
Medulla oblongata
Cerebellum
Spinal cord
Embryo at 1 month
Embryo at 5 weeks
Child


Motor cortex (control of skeletal muscles)
Somatosensory cortex (sense of touch)
Frontal lobe
Parietal lobe
Prefrontal cortex (decision making, planning)
Sensory association cortex (integration of sensory information)
Broca's area (forming speech)
Visual association cortex (combining images and object recognition)
Temporal lobe
Occipital lobe
Auditory cortex (hearing)
Visual cortex (processing visual stimuli and pattern recognition)
Wernicke's area (comprehending language)
Cerebellum


Knee
Hip
Trunk
Shoulder
Elbow
Forearm
Wrist
Hand
Fingers
Thumb
Neck
Brow
Eye
Face
Lips
Jaw
Tongue
Toes
Primary motor cortex
Leg
Hip
Trunk
Neck
Head
Upper arm
Elbow
Forearm
Hand
Fingers
Thumb
Eye
Nose
Face
Lips
Genitalia
Teeth
Gums
Jaw
Tongue
Pharynx
Abdominal organs
Primary somatosensory cortex


Inhibitory neuron
Nicotine stimulates dopamine-releasing VTA neuron.
Opium and heroin decrease activity of inhibitory neuron.
Dopamine-releasing VTA neuron
Cocaine and amphetamines block removal of dopamine from synaptic cleft.
Cerebral neuron of reward pathway
Reward system response

Chapter 49 Questions

1. **How many neurons does the human brain have?**
2. **What is a nerve net?**
3. **What are nerves?**
4. **What is cephalization?**
5. **What is a central nervous system?**
6. **What is a peripheral nervous system?**
7. **Describe the nervous systems of echinoderms, flatworms, annelids, arthropods, molluscs, and vertebrates.**
8. **How many neurons do adult *C. elegans* worms have?**
9. **How do the nervous systems of molluscs differ?**
10. **Describe the glia of the vertebrate nervous system.**
11. **What glia play a role in development of nervous system in embryos?**
12. **What originates from the cavity of the nerve cord?**
13. **What is gray matter?**
14. **What is white matter?**
15. **Describe the location of gray and white matter.**
16. **What are reflexes?**
17. **What does hitting your knee with a mallet test?**
18. **What is afferent sensory information?**
19. **What is efferent sensory info?**
20. **What is the motor system?**
21. **What is the autonomic nervous system?**
22. **What is the enteric nervous system?**
23. **What is the sympathetic division?**
24. **What is the parasympathetic division?**
25. **What are preganglionic neurons?**
26. **What are postganglionic neurons?**
27. **What is the forebrain?**
28. **What is the midbrain?**
29. **What is the hindbrain?**
30. **Describe the formation of brain structures in humans.**
31. **What is the cerebrum?**
32. **What is the cerebral cortex?**
33. **What is the corpus callosum?**
34. **What are basal nuclei?**
35. **What is cerebral palsy?**
36. **What is the cerebellum?**
37. **What does the diencephalon give rise to?**
38. **What are the three parts of the brainstem?**
39. **What is arousal?**

40. What is sleep?
41. How are brain waves recorded?
42. What is the reticular formation?
43. How do bottlenose dolphins swim while sleeping?
44. What is a biological clock?
45. What is the sleep/wake cycle of humans in constant environment?
46. What is the suprachiasmatic nucleus (SCN)?
47. What is the limbic system?
48. What is the amygdala?
49. What is responsible for laughing and crying?
50. What is autonomic arousal?
51. How does positron-emission tomography work (PET)?
52. What is functional magnetic resonance imaging (fMRI)?
53. How does perception of happiness and sadness differ?
54. What is the largest structure in the human brain?
55. What are sensory areas?
56. What are association areas?
57. What are motor areas?
58. Name and place the regions of the cerebral cortex.
59. What are somatosensory receptors?
60. Describe the path of sensory information.
61. How is the somatosensory cortex organized?
62. What trend is there in terms of region size in the brain?
63. What is Broca's area?
64. What is Wernicke's area?
65. What is lateralization?
66. What is a "split-brain" effect?
67. What is the role of the frontal lobe?
68. What is frontal lobotomy?
69. What are cetaceans?
70. Where are extensively convoluted cerebral cortices found?
71. How do birds process information without convoluted cortex?
72. How are neurons arranged in the human brain?
73. What are the steps of nervous system formation?
74. What is neuronal plasticity?
75. What is autism?
76. What contributes to short term memory?
77. How are memories made long term?
78. What is long-term potentiation?
79. What is schizophrenia?
80. What is amphetamine ("speed")?
81. What is PCP ("angel dust")?
82. What is major depressive disorder?

83. What is bipolar disorder (manic-depressive disorder)?
84. What is fluoxetine (Prozac)?
85. What is the reward system?
86. What is the ventral tegmental area (VTA)?
87. What is drug addiction?
88. Describe how different drugs affect reward system.
89. What is Alzheimer's disease?
90. What is Parkinson's disease?

Chapter 49 Answers

1. Estimated 10^{11} (100 billion)
2. In cnidarians, interconnected neurons, diffuse, controls contraction/expansion of gastrovascular cavity
3. Bundles of axons
4. Evolutionary trend towards clustering of sensory neurons/interneurons at anterior
5. Made of of neurons that carry out integrations
6. Neurons that carry information to/from CNS
7. Sea stars have set of radial nerves linked to nerve net in each arm. Certain nonsegmented worms have very few nervous cells. Segmented worms and arthropods have many more, regulated by brains and ganglia (segmentally arranged clusters of neurons). See picture
8. exactly 302
9. Sessile/slow-moving have simple sense organs and little cephalization. Active predators have most sophisticated nervous systems of invertebrates
10. Support cells, see picture.
11. Radial glia form tracks along which new neurons migrate from neural tube (structure that gives rise to CNS). Astrocytes adjacent to brain capillaries participate in formation of blood-brain barrier. Both can act as stem cells
12. Central canal of spinal cord, ventricles of brain (fill with cerebrospinal fluid (formed by filtering arterial blood))
13. Neuron cell bodies
14. Bundled axons
15. White matter forms outer layer of spinal cord, inner layer of brain
16. Body's automatic responses to certain stimuli, produced by spinal cord as part of simple nerve circuits
17. Taps tendon connected to quadriceps, stretch causes quadriceps to contract and jerk leg forward, motor neurons of hamstring inhibited, provides immediate protective response after picking up heavy object see picture
18. Info from PNS to CNS
19. Info from CNS to PNS
20. Efferent component of PNS, carries signals to skeletal muscles, can be voluntary or involuntary
21. Efferent component of PNS, regulates smooth and cardiac muscles, generally involuntary. Sympathetic/parasympathetic divisions regulate digestive, cardiovascular, excretory, and endocrine systems
22. Distinct network of neurons exerting direct/partially independent control over digestive tract, pancreas, and gallbladder
23. Corresponds to arousal and energy generation, e.g. fight or flight. Typically exit CNS midway along spinal cord and form synapses in ganglia outside spinal cord

24. Causes opposite responses that promote calming and return to self-maintenance functions (rest and digest). Complements sympathetic division in reproductive activity. Nerves exit CNS at base of brain/spinal cord, form synapses in near or within an internal organ. See picture
25. Have cell bodies in CNS, release acetylcholine as neurotransmitter
26. Others, in parasympathetic release acetylcholine, in sympathetic release norepinephrine
27. Contains olfactory bulb and cerebrum, process olfaction, regulates sleep, learning (any complex processing)
28. Coordinates routing of sensory input
29. Part of it forms cerebellum, controls involuntary activities and coordinates motor activities
30. See picture
31. Controls skeletal muscle contraction, center for learning, emotion, memory, and perception. Divided into right/left cerebral hemispheres
32. Outer layer of cerebrum, vital for perception, voluntary movement, and learning. Left side receives info and controls right side of body
33. Thick band of axons that enables left/right cerebral cortices to communicate
34. Clusters of neurons deep in white matter, plan and learn movement sequences
35. Disorder resulting from disruption in transmission of motor commands to muscles, may result from damage to basal nuclei during fetal development
36. Coordinates movement and balances, helps in learning/remembering motor skills. Receives info about position of body and input from auditory/visual systems. Monitors cerebral commands. Responsible for hand-eye coordination
37. Thalamus - main input center for sensory information to cerebrum. Formed by two masses (size/shape of walnut)
    Hypothalamus - smaller structure, constitutes control center including thermostat/clock
    Epithalamus - includes pineal gland (source of melatonin)
38. Midbrain = receives/integrates sensory info. All hearing axons terminate in midbrain or pass through it. Coordinates visual reflexes
    Pons/medulla - transfer info from PNS to midbrain/forebrain, axons cross from one side of CNS to other side in medulla. Medulla homeostatic functions with help of pons
39. State of awareness of external world
40. State in which external stimuli are received but not consciously perceived
41. Electroencephalogram (EEG) that records patterns of electrical activity
42. Diffuse network formed primarily by neurons in midbrain/pons, control timing of sleep periods characterized by rapid eye movements (REMs) and vivid dreams
43. Dolphin sleep with one eye open, one side of brain asleep at a time
44. Molecular mechanism that directs periodic gene expression and cellular activity
45. 24.2 hours, little variation
46. Clustered neurons in hypothalamus that coordinate circadian rhythms, acts as pacemaker, synchronize biological clock in cells
47. Includes amygdala, hippocampus, and parts of thalamus, controls generation/experience of emotions, border brainstem in mammals. Stores memories that can be recalled by similar circumstances

48. Almond-shaped mass of nuclei located near base of cerebrum
49. Limbic system interacting with sensory areas of forebrain
50. Increased heart rate or sweating from stimuli due to prior experience
51. Injection of radioactive glucose enables display of metabolic activity
52. Subject lies with head in center of large doughnut-shaped magnet, brain activity detected by increase in flow of oxygen-rich blood into particular region
53. Listening to sad music has increased activity in amygdala, happy in nucleus accumbens (brain structure important to pleasure)
54. Cerebrum
55. Areas of cerebral cortex that receive/process sensory info
56. Integrate information
57. Transmit instructions to other parts of body
58. See picture
59. Individual receptors in body
60. Directed via thalamus to primary sensory areas. Information passed to nearby association areas. Info passes to prefrontal cortex that helps plan actions/movement, may generate motor commands
61. Legs and feet information processing lie in region closest to midline. Leg and feet commands generated in corresponding motor cortex position. See picture
62. Forebrain increasingly prominent in vertebrate phylogenetic tree
63. Small region in left frontal lobe, needed to form speech
64. Posterior portion of left temporal lobe, needed to understand speech
65. Difference in function between right and left hemispheres (left for math and logical operations, right for recognition of patterns, spatial relations, and nonverbal thinking)
66. When corpus callosum damaged (severed to treat epilepsy), hemispheres function independently
67. Decision-making, emotional responses, executive functions
68. Severing of connection between prefrontal cortex and limbic system, used to be treatment for behavioral disorders, no longer in use
69. Whales, dolphins, and porpoises
70. Primates and cetaceans, in humans cortex = 80% of brain mass
71. Clustered organization of neurons within pallium (top/outer portion of brain), instead of layers
72. 6 parallel layers arranged tangential to surface
73. First, regulated gene expression/ signal transduction determine where neurons form in embryo. Neurons compete for growth-supporting factors, only received if get to right location (otherwise undergo apoptosis) (half of neurons eliminated). Synapse elimination takes place during dev, each neuron forms many synapses, activity stabilizes some synapses, destabilizes others. (more than half synapses pruned, called synaptic pruning, continues throughout childhood)
74. Capacity of nervous system to be remodeled in response to its own activity

75. Disorder that results in impaired communication and social interaction, and stereotyped and repetitive behaviors beginning in early childhood (may involve disruption of plasticity)
76. Information accessed by temporary links in hippocampus
77. Links in hippocampus replaced by connections within cerebral cortex itself, thought to occur during sleep, reactivation of hippocampus for consolidation likely causes dreams
78. Lasting increase in the strength of synaptic transmission. Glutamate binds to NMDA to open it, but still blocked by Mg^{2+}. Depolarization of postsynaptic membrane causes Mg^{2+} release. Unblocked receptors allow influx of Na^{+} and Ca^{2+}, trigger insertion of stored AMPA receptors. Glutamate activates AMPA receptors to trigger depolarization
79. 1% of world's population, severe mental disturbance characterized by psychotic episodes where patients have distorted perception of reality. Caused by fragmentation of normally integrated brain function. Neuronal pathways that use dopamine disrupted, blocking dopamine receptors with drugs alleviates symptoms, may be caused by blocking of glutamate receptors
80. Drug that stimulates dopamine release, produces same set of symptoms of schizophrenia
81. Drug that blocks glutamate receptors,causes schizophrenia-like symptoms
82. Undergo periods (often many months) when enjoyable activities provide no pleasure/interest, one of most common nervous system disorders, one in seven adults, twice as many women
83. Extreme swings of mood, 1% of population. Manic phase characterized by high self-esteem, increased energy, flow of ideas, over talkativeness, risk taking, sometimes with great creativity. Depressive phase = lessened motivation, sense of worth, ability to feel pleasure + sleep disturbance.
84. Drug used to treat depressive illness by increasing activity of biogenic amines
85. Provides motivation for activities that enhance survival and reproduction
86. Area near base of brain, receives inputs to reward system, release dopamine, targets nucleus accumbens and prefrontal cortex
87. Disorder characterized by compulsive consumption of drug, drugs enhance activity of dopamine pathway.
88. See picture
89. Mental deterioration, or dementia, characterized by confusion/memory loss. Rises from 10% at 65, 35% at 85. Progressive, brain tissue has neurofibrillary tangles (made up of tau protein, normally assembles/maintains microtubules that transport nutrients, undergoes changes to make it bind to itself) surrounding plaques of ß-amyloid (insoluble peptide cleaved from extracellular portion of membrane protein in neurons, secretases catalyze cleavage, causing accumulation, triggers death of surrounding neurons). Often massive shrinkage of brain tissue, death of neurons in many areas of brain (hippocampus and cerebral cortex)
90. Motor disorder, muscle tremors, poor balance, shuffling, flexed, facial muscles rigid, cognitive defects, progressive. 1% at 65, 5% at 75. 1million in US. involves death of neurons in midbrain that normally release dopamine at synapses in basal nuclei. Protein

aggregates accumulate. Early onset has clear genetic basis (disruption of certain mitochondrial functions). Can be treated not cured (brain surgery, deep-brain stimulation, L-dopa (crosses blood brain barrier, dopa decarboxylase converts it to dopamine))