A neuron (nervous system cell) receives signals at the denrites and propgates information (as action potential firing) to its synapse via axons.
Nervous systems originated from systems of sensory and motor neurons.

- Sea jelly nerve nets control contraction/expan.
- Sea star radial nerves for each arm contracts, connected to central nerve ring.
- Central nervous system integrate at anterior end & spine, peripheral system nerves ganglia.
- Glial cells (non-neurons) protect and nourish neurons, e.g. Schwann cells produce myelin sheats surrounding axons in PNS for speed.

(a) Hydra (cnidarian)  (b) Sea star (echinoderm)  
(c) Planarian (flatworm)  (d) Leech (annelid)
Vertebrate nervous systems are grouped into circuits.

- Cavity of embryonic nerve cord becomes central canal of spinal cord and brain ventricles, filled with cerebrospinal fluid.
- Gray matter: neuron cell bodies.
- White matter: axon bundles myelinated, exterior in periphery, interior in CNS for region signaling.
- Spinal cord communicates CNS and PNS, but also indep in reflexes (bypassing CNS).
- Knee jerk reflex function at only spinal cord level.
Gray matter
White matter
Ventricles

Central nervous system (CNS)

Brain
Spinal cord
Cranial nerves
Ganglia outside CNS
Spinal nerves

Peripheral nervous system (PNS)
Peripheral nervous system consists of motor and autonomic systems.

- Afferent: PNS to CNS, efferent: CNS to PNS
- PNS motor system: signal to skeletal muscles
- PNS autonomic: involuntary, cardiac and smooth muscles, enteric digestive glands
- PNS autonomic sympathetic: arousal, digestion down, glucose conv, just outside spinal cord ganglia, post ganglia norepinephrine
- PNS autonomic parasympathetic: rest digest, glycogen prod, sex functions up along symp, base of brain to ganglia near organ, post ganglia ACh
Afferent neurons
Sensory receptors
Internal and external stimuli

Efferent neurons
Autonomic nervous system
Motor system
Control of skeletal muscle

Sympathetic division
Parasympathetic division
Enteric division
Control of smooth muscles, cardiac muscles, glands

CENTRAL NERVOUS SYSTEM
(information processing)

PERIPHERAL NERVOUS SYSTEM

Parasympathetic division
- Constricts pupil of eye
- Stimulates salivary gland secretion
- Constricts bronchi in lungs
- Slows heart
- Stimulates activity of stomach and intestines
- Stimulates activity of pancreas
- Stimulates gallbladder
- Promotes emptying of bladder
- Promotes erection of genitalia

Sympathetic division
- Dilates pupil of eye
- Inhibits salivary gland secretion
- Relaxes bronchi in lungs
- Accelerates heart
- Inhibits activity of stomach and intestines
- Inhibits activity of pancreas
- Stimulates glucose release from liver; inhibits gallbladder
- Stimulates adrenal medulla
- Inhibits emptying of bladder
- Promotes ejaculation and vaginal contractions

e.g. exercise: symp up, parasymp down
Regional specific components of evolved brain structures.

- Forebrain: complex processing, midbrain: routing inputs, hindbrain: involuntary activity movement
- Forebrain got bigger in evolution, region specific
- Human cerebral cortex: left control right, corpus callosum cross-over, learning perception etc
- Cerebellum: error check move, eye-hand coord
- Diencephalon: thalamus relay sensory info, hypothalamus hunger thirst, body temperature, bio clock, pituitary control, pineal gland: melatonin CSF
- Brainstem: pons and medulla, relay, breathing, heart, swallowing vital functions, cross-over, vis reflex

**Key**
- Forebrain
- Midbrain
- Hindbrain
Embryonic brain regions

- Telencephalon
- Diencephalon
- Mesencephalon
- Metencephalon
- Myelencephalon

Brain structures in child and adult

- Cerebrum (includes cerebral cortex, basal nuclei)
- Diencephalon (thalamus, hypothalamus, epithalamus)
- Midbrain (part of brainstem)
- Pons (part of brainstem), cerebellum
- Medulla oblongata (part of brainstem)

Embryo at 1 month

- Forebrain
- Midbrain
- Hindbrain

Embryo at 5 weeks

- Forebrain
- Midbrain
- Hindbrain
- Spinal cord

Child

- Cerebrum
- Diencephalon
- Midbrain
- Pons
- Medulla oblongata
- Cerebellum
- Spinal cord

Figure 49.11c

Adult brain viewed from the rear

- Left cerebral hemisphere
- Right cerebral hemisphere
- Cerebral cortex
- Corpus callosum
- Basal nuclei
- Cerebellum
Sleep, arousal, and circadian rhythms are regulated by midbrain control.

- Sleep: recording EEG waves, evidence for consolidation replay, midbrain reticular formation control REM rapid eye move dream filter input
- Dolphin: sleep one hemisphere at a time
- Biological clock sync to light and dark: hypothalamus
- Hypothalamic suprachiasmatic nucleus SCN transplant b/t 20 and 24 hr hamster strains - SCN as pacemaker
Figure 49.12

Eye

Reticular formation

Input from touch, pain, and temperature receptors

Input from nerves of ears

Figure 49.13

Key

- Low-frequency waves characteristic of sleep
- High-frequency waves characteristic of wakefulness

<table>
<thead>
<tr>
<th>Location</th>
<th>Time: 0 hours</th>
<th>Time: 1 hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Left hemisphere</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Right hemisphere</td>
<td></td>
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</tbody>
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Emotions rely on interplay within limbic system: amygdala, hippocampus

- Image followed by shock lead to autonomic arousal heart rate sweating, but amygdala damage -> no arousal but can recall image
- fMRI of human tracks change in local oxygen level, listen to happy or sad music: happy -> nucleus accumbens activated, sad -> amygdala
Myelinated neurons are especially abundant in the _____.

- A) white matter of the brain and the gray matter of the spinal cord
- B) white matter in the brain and the white matter in the spinal cord
- C) gray matter of the brain and the gray matter of the spinal cord
- D) gray matter of the brain and the white matter of the spinal cord

If a patient has an injury in the brain stem, which of the following would be observed?

- A) an inability to regulate body temperature
- B) an inability to regulate heart function
- C) auditory hallucinations
- D) visual hallucinations
Cerebral cortex consists of sensory, association, and motor areas.

- Visual auditory somatosensory receptors -> thalamus -> primary sensory area (particular feature) -> association area (recognition faces) -> prefrontal (action planning) -> motor cortex -> brainstem -> spinal cord -> motor neurons
- Topographical organization in sensory and motor cortices, proportional to amount of processing needed for that body part
- Broca’s area damage: can understand - not speak, Wernicke’s damage: can’t comprehend - can talk
• Left hemisphere: language, logic, math
• Right hemisphere: recognition, spatial, pattern
• Split brain severing of corpus callosum: cannot read word in left visual field since info cannot go from right hemisphere to language area
• Frontal lobe: Phineas Gage explosion caused iron rod behind left eye recovered, detached personality erratic behavior, no exec control
• Evolution: unconvoluted pallium in birds and convoluted cortex in humans from same ancestor? Birds can remember, tools, abstract

Skull of Phineas Gage, railroad construction crew
Learning and memory are formed by changes in cell, synaptic connections.

- Competition for growth factors: **cell** death for half of cells who don’t reach proper location.
- Competition for right connections: half of **synapses** for a cell are eliminated in develop.
- Neuronal plasticity: activity of cell -> remodel, fire together -> wire together, autism defect.
- Hippocampus short term memory, cortex long term memory, damage to hippocampus: can recall past but not form new memories.
Changes in synaptic strength at the hippocampus via LTP.

- More connections with existing knowledge the new knowledge is, easier it’s to remember
- New skill: new connects, new fact: use existing
- Long term potentiation in hippocampus: high freq presyn firing coincides with postsyn depolarization -> unblock NMDAR -> insertion of AMPAR glutamate receptors -> bigger postsyn potential with the usual presyn stim

(a) Connections between neurons are strengthened or weakened in response to activity.

(b) If two synapses are often active at the same time, the strength of the postsynaptic response may increase at both synapses.
Nervous system disorders can affect anyone.

- Family studies to identify genetic factors
- Schizophrenia: disordered reality, hallucinates, delusions, dopamine block alleviates symptom
- Depression: major depressive, bipolar manic phase suicidal phase, Prozac amines up
- Addiction: manipulate VTA dopamine pathway
- Alzheimer’s: can’t function can’t recognize, accumulate beta amyloid plagues that kill cells nearby, neurofibrillary tau tangles (early onset)
- Parkinson’s: tremors rigid shuffling, mitochondria genetic defect?, L-Dopa and deep brain stim
Addiction

Nicotine stimulates dopamine-releasing VTA neuron.

Inhibitory neuron

Dopamine-releasing VTA neuron

Opium and heroin decrease activity of inhibitory neuron.

Cocaine and amphetamines block removal of dopamine from synaptic cleft.

Cerebral neuron of reward pathway

Reward system response

Alzheimer’s disease: molecular aspects.

Amyloid plaque Neurofibrillary tangle 20 µm
Team activity

The motor cortex is part of the _____.
  • A) spinal cord
  • B) cerebrum
  • C) medulla oblongata
  • D) cerebellum

Exercise and emergency reactions include _____.
  • A) decreased activity in the sympathetic, and increased activity in the parasympathetic divisions
  • B) increased activity in all parts of the peripheral nervous system
  • C) increased activity in the enteric nervous system
  • D) increased activity in the sympathetic, and decreased activity in the parasympathetic divisions