PCB 4843
Fundamentals of Neuroscience

Instructor:

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Canvas:

Lectures will be posted at least the day before class under "Course Files"

Lecture 1: Overview of the Nervous System

Navigational Terms

Supracellular Features of Vertebrate Nervous System

Pharmacological Approach to the Nervous System

Levels of Analysis of A Neuron

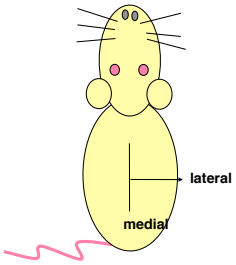
Lecture 2: Review of Neurons & Cellular Biology

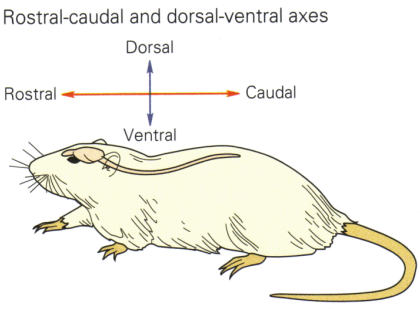
3 Spatial Axes of the rat nervous system

Quadraped:
rostral -- towards nose
caudal -- towards tail

dorsal -- towards back
ventral -- towards belly

medial -- toward center
lateral -- toward side





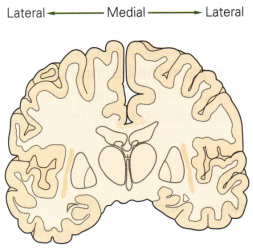
3 Spatial Axes of the human nervous system

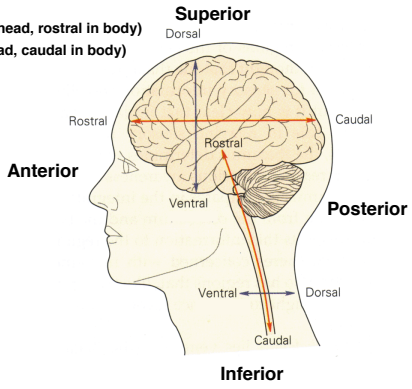
Human:

anterior -- towards face (rostral in head, ventral in body)
posterior -- towards back (caudal in head, dorsal in body)

superior -- toward head (dorsal in head, rostral in body)
inferior -- toward feet (ventral in head, caudal in body)

medial -- toward center
lateral -- toward side





Supracellular Features of Vertebrate Nervous System

1. **Centralized brain and spinal cord**
2. **Dorsal placement and lateral symmetry**
3. **Peripheral nervous system**
4. **Segmentation of nervous system**
5. **Central vs. Peripheral nervous systems**

Vertebrate Body Plan

Notochord/Vertebrae along dorsal spinal cord

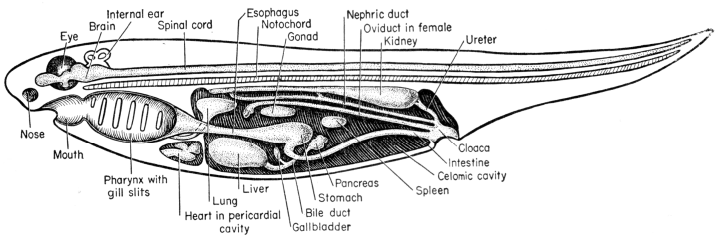
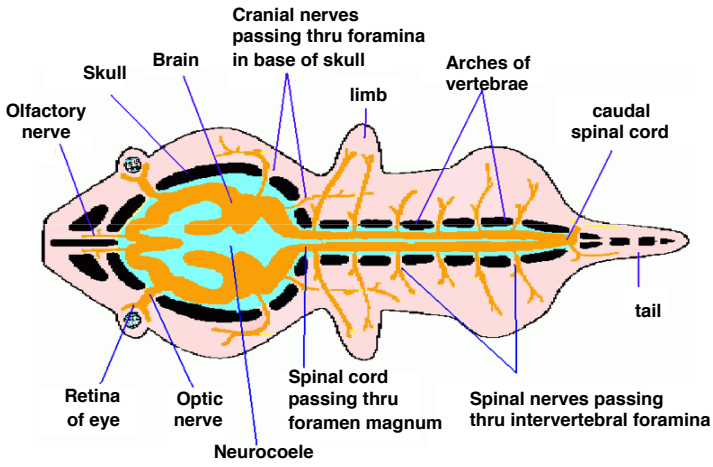
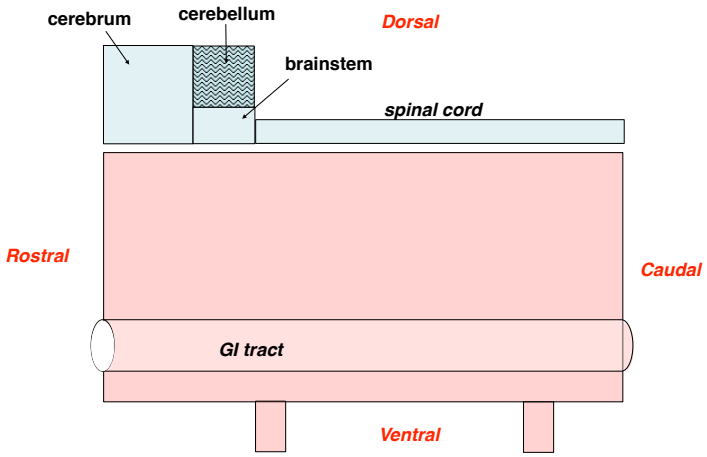


FIGURE 1. Diagrammatic longitudinal section through an "idealized" vertebrate, to show the relative position of the major organs.

Simplified Plan of the Nervous System of a Generalized Vertebrate

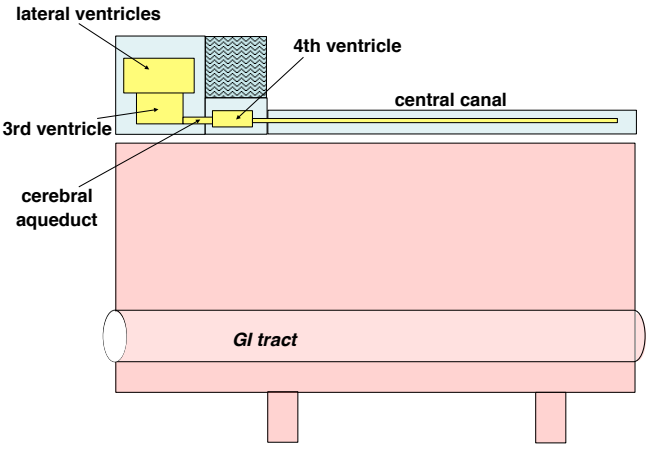


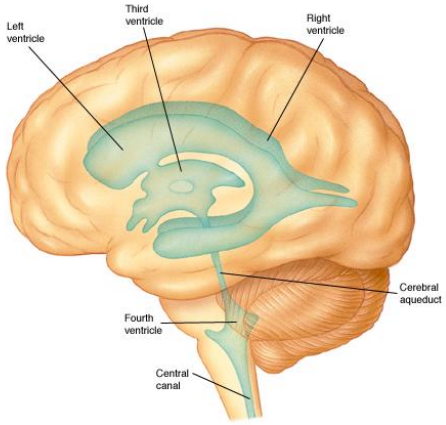
Vertebrate Central Nervous System

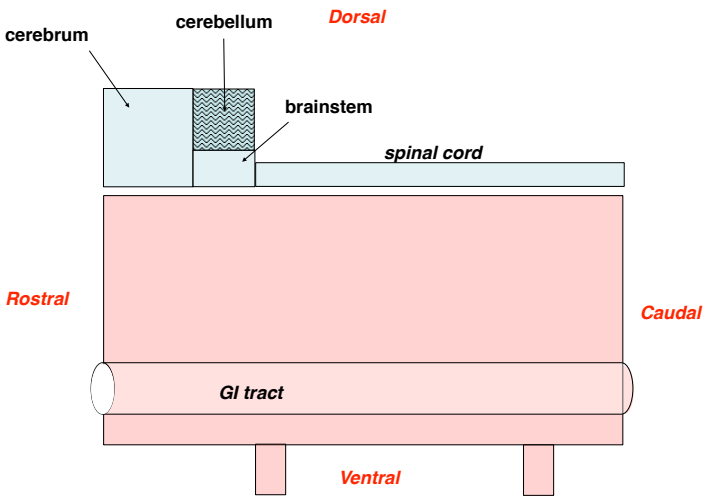


Cerebral Ventricles and Central Canal:

Spaces within the brain and spinal cord filled with cerebral spinal fluid (CSF)

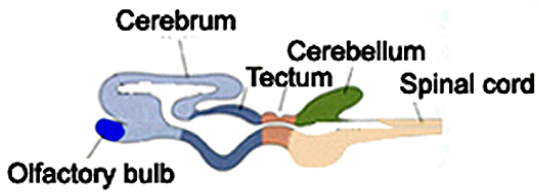






Spinal Cord, Brainstem, Cerebellum, Cerebrum

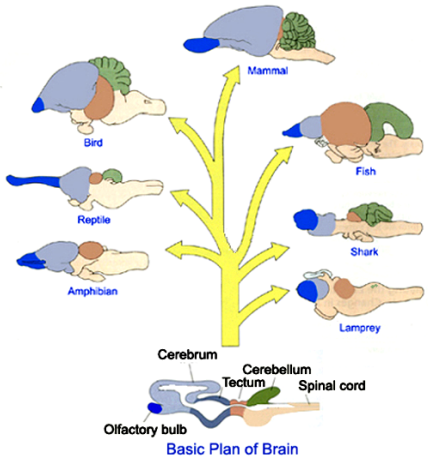
CNS structures common to all vertebrates (along with optic tectum and olfactory bulb)



Basic Plan of Brain

Spinal Cord, Brainstem, Cerebellum, Cerebrum

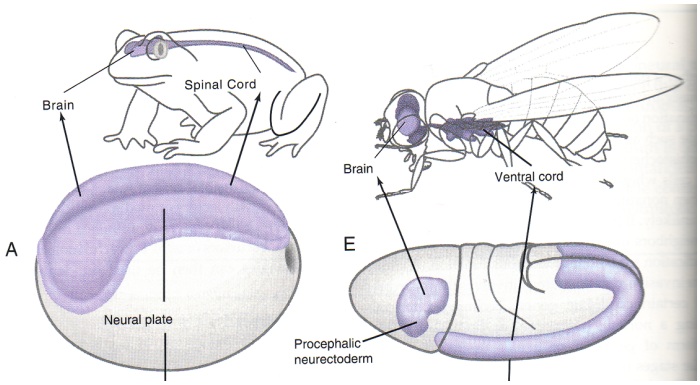
CNS structures common to all vertebrates (along with optic tectum and olfactory bulb)



Basic Plan of Brain

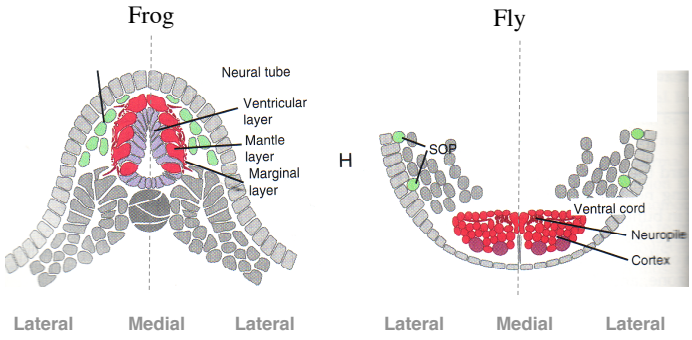
Dorsal placement of Vertebrate CNS

vs. Ventral placement of Invertebrates

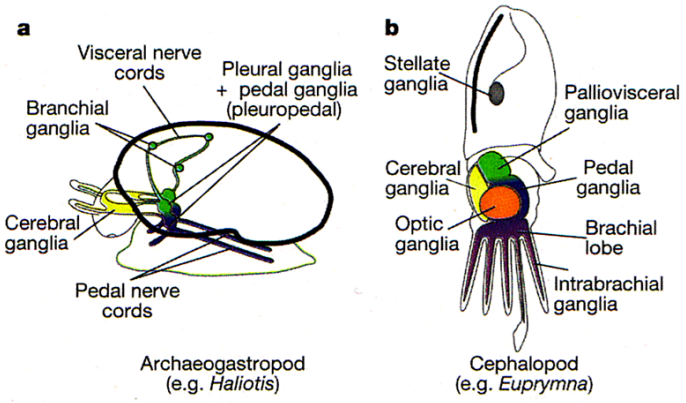


Bilateral Symmetry

a result of symmetrical development of Nervous System from midline



Bilateral Symmetry is not a given...



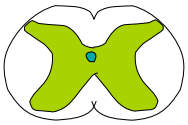
7 parts of the Mammalian Central Nervous System

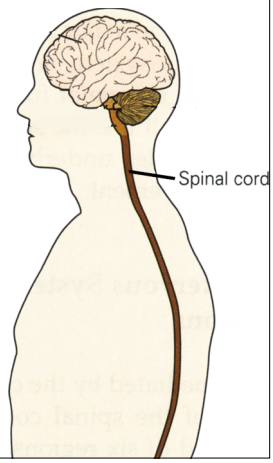
1. Spinal cord

from base of skull to lumbar vertebra

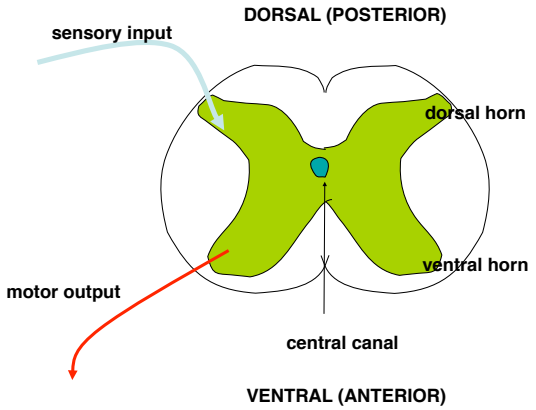
sensory info from trunk & limbs

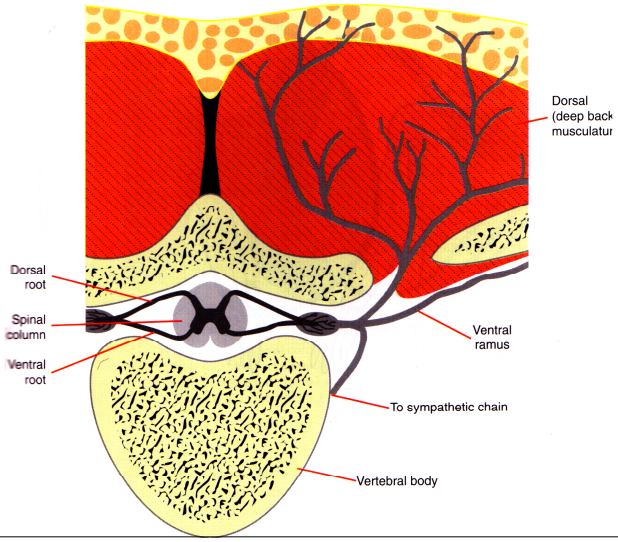
voluntary & reflex & autonomic motor output



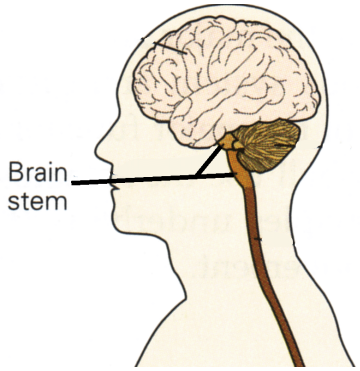


1. Spinal Cord





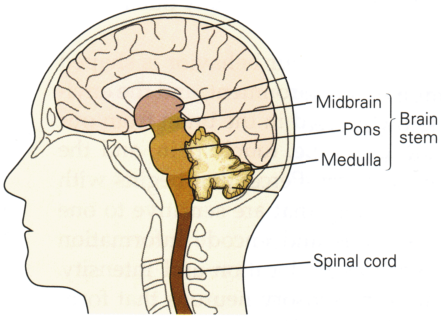
2-3. Brainstem: Medulla, Pons, Midbrain



2. Medulla (core)

"Autonomic spinal cord"

Blood pressure, breathing, feeding and GI functions & reflexes



3. Pons (bridge)

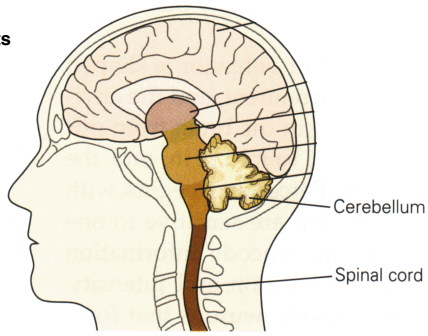
Relays from cortex & spinal cord to cerebellum
Sleep

4. Midbrain

Final limb movements (site of Parkinsons), eye movements

5. Cerebellum (little brain)

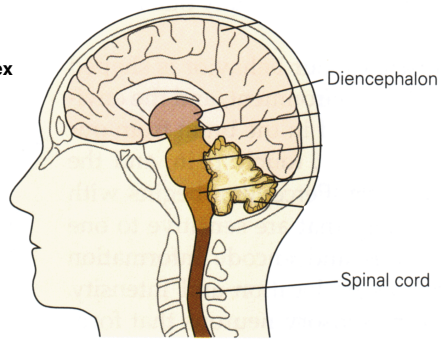
Motor learning
Motor coordination
Posture & eye movements



6. Diencephalon

1. Thalamus (chamber)
Relay & modulatory of sensory input to the cortex

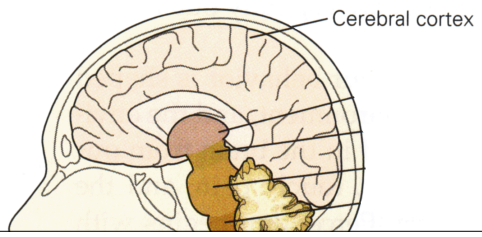
2. Hypothalamus (under the thalamus)
homeostasis, reproduction, primary behaviors



7. Cerebral hemispheres

a. Cerebral Cortex (bark)
perception, cognition, movement
b. Basal ganglia
movement
c. Amygdala (almond)
emotions
d. Hippocampus (sea horse)
memory

two hemispheres connected by corpus callosum



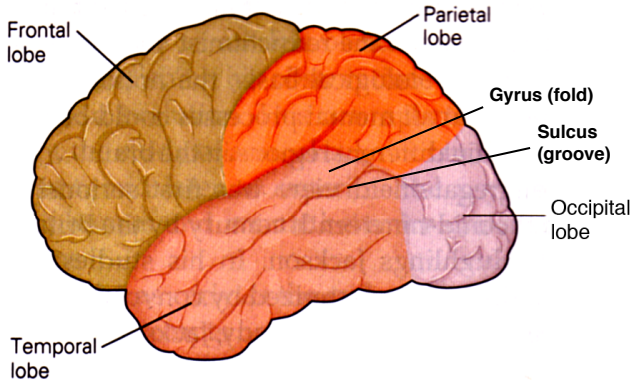
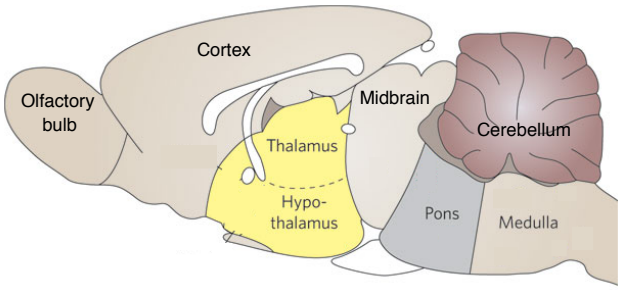
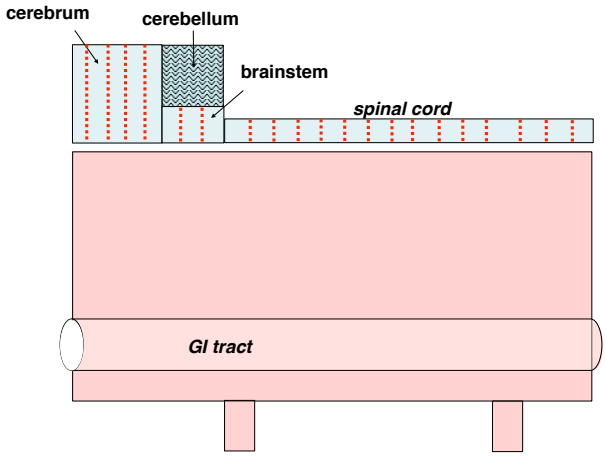


Figure 1-2B The four lobes of the cerebral cortex.

Sagittal rat brain

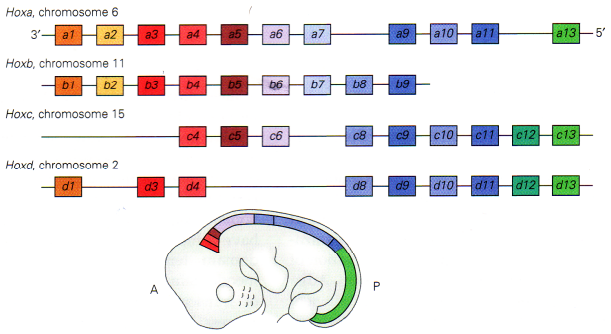


Segmentation of the Nervous System



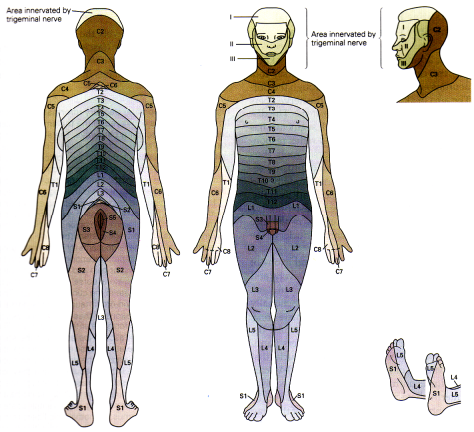
Segmentation of the Spinal Cord

Functional result of developmental plan



One Dorsal root ganglion approx. for each vertebra:

(DRG = cell bodies of spinal sensory neurons)
receptive fields of one DRG = dermatome



herpes varicella zoster virus

Chicken Pox

Shingles

A.D.A.M.

Shingles, or herpes zoster, is caused by the same virus that causes chickenpox. The virus can lie dormant in the body for many years and re-emerge as shingles. Shingles appear as a painful rash. It consists of red patches of skin with small blisters (vesicles) that look very similar to early chickenpox. Shingles usually clears in 2 to 3 weeks and rarely recurs.

http://en.wikipedia.org/wiki/File:Child_with_chickenpox.jpg

https://health.google.com/health/ref/Herpes+zoster

Infection by neural virus that lives in DRG cells: herpes zoster (shingles or chicken pox)

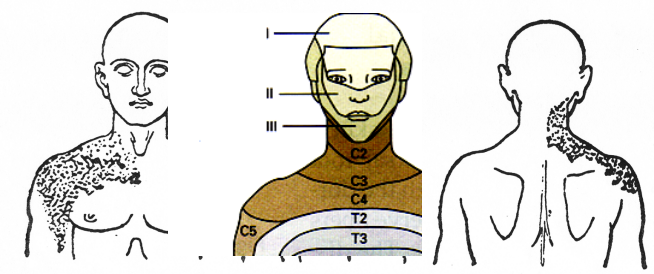
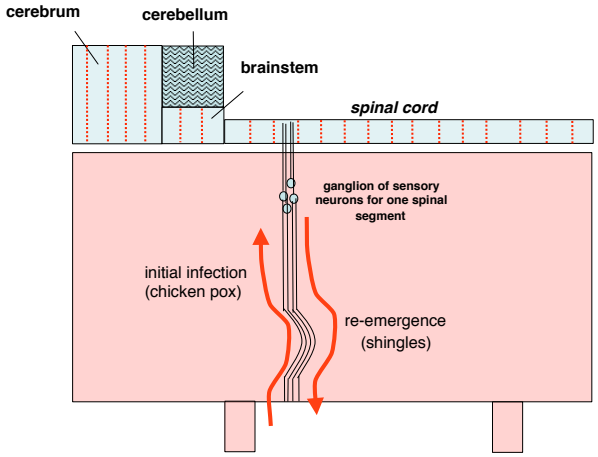


Figure 10.9. Head and Campbell (1900) compared the rashes in individual cases of herpes zoster, like the one shown above, to map the dermatomes in humans.

Segmentation of the Nervous System



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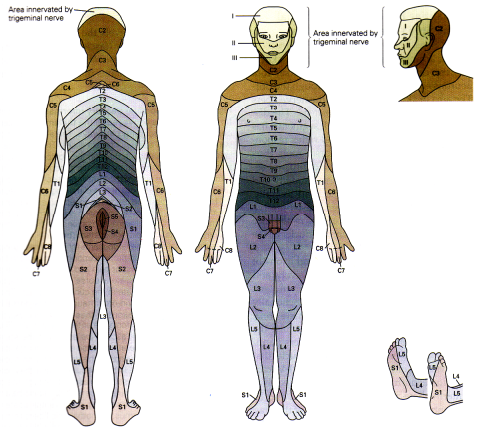
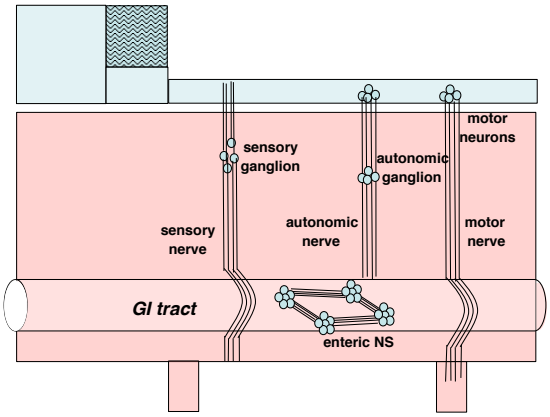


Peripheral Nervous System:

Neurons and nerve fibers outside the brain and spinal cord



Peripheral nervous system

(outside brain and spinal cord)

Motor nerves that from brain and spinal cord to run muscles
Sensory nerves with cell bodies in periphery

Somatic nervous system:

nerves that allow us to consciously sense and move our body

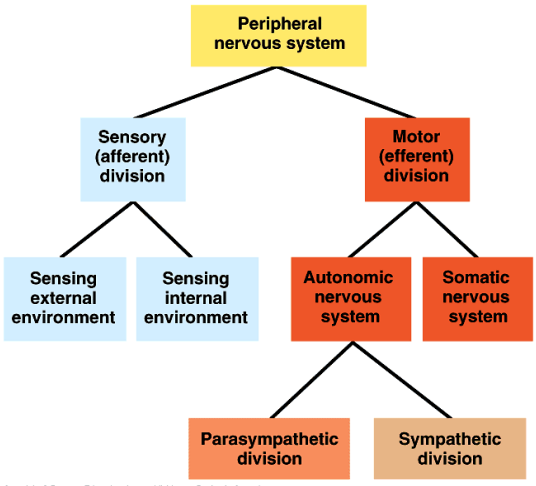
Autonomic nervous system:

nerves that unconsciously monitor and run organs, glands, etc.

Sympathetic nervous system: ***fight or flight***
Parasympathetic nervous system: ***rest and digest***

Enteric nervous system:
very indepedent, hydra-like network that runs the gut

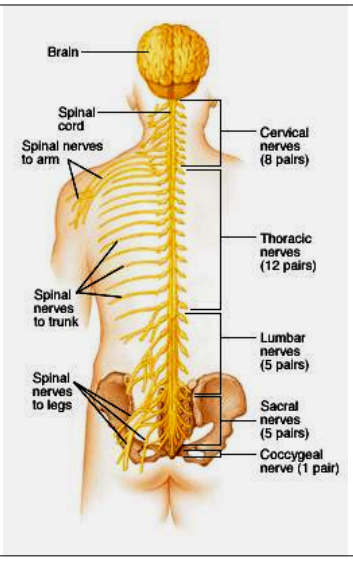
Functional hierarchy of the peripheral nervous



Spinal Cord

Somatic Nervous System

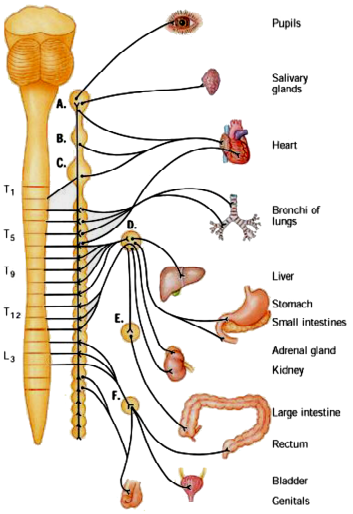
gets inputs from sensory receptors and sends output to skeletal muscles



Sympathetic Nervous System

Nerves from spinal cord run to chain ganglia and then to glands and smooth muscle

mobilize energy
divert blood to muscle
prepare to fight/flee

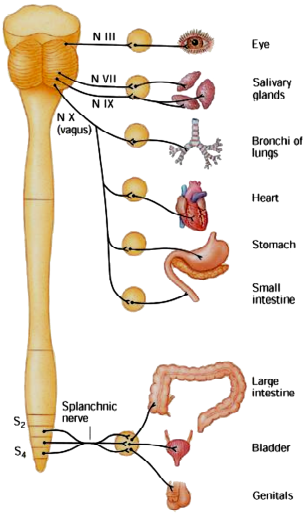


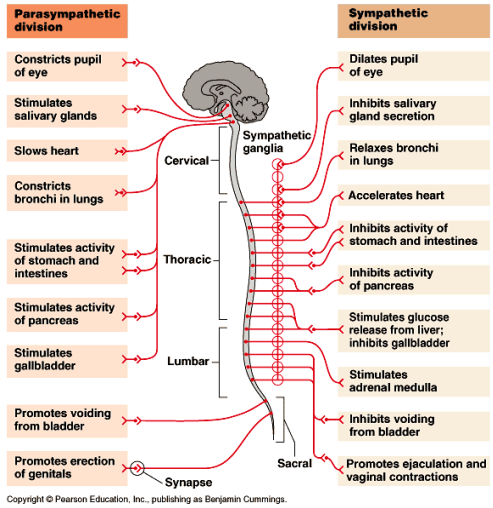
Parasympathetic Nervous System

Nerves from brainstem and spinal cord run to glands and smooth muscle

Prepare for digestion, energy storage, divert blood flow to gut.

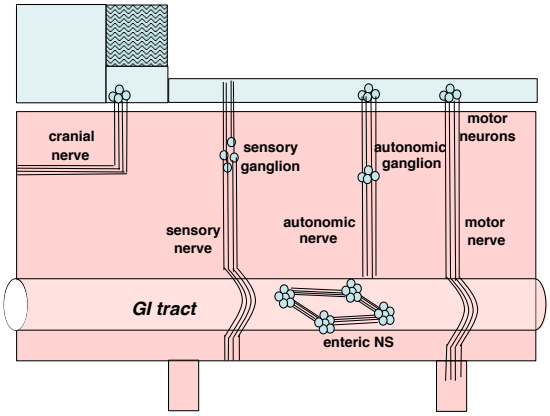
opposite effect of sympathetic NS





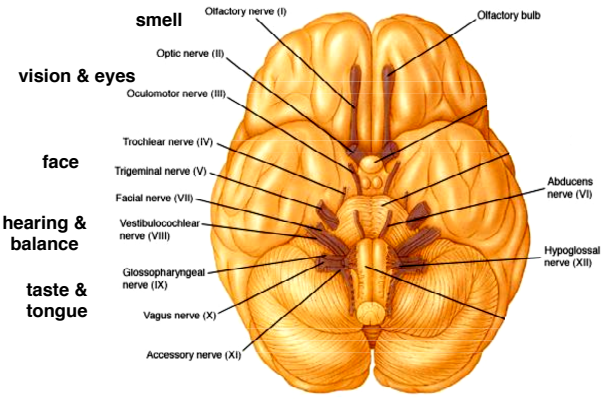
Peripheral Nervous System:

Neurons and nerve fibers outside the brain and spinal cord



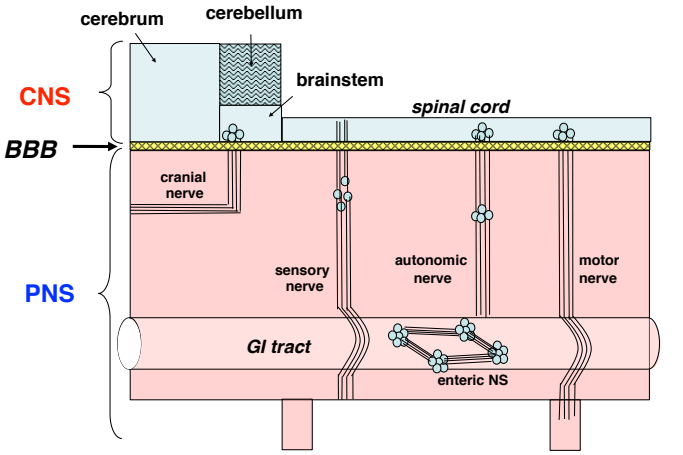
Cranial Nerves

Sensory and motor nerves that come straight to and from the brain



Central vs Peripheral Nervous System

chemically separated by Blood-Brain Barrier



Blood Brain Barrier

BBB excludes large hydrophilic molecules like peptides, toxins, many drugs.

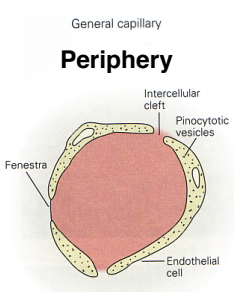
Specific transporter enzymes on endothelial cells carry glucose, amino acids across BBB.

Small molecules (e.g. O_2, CO_2) can pass and hydrophobic molecules like steroids can also pass through cell membranes.

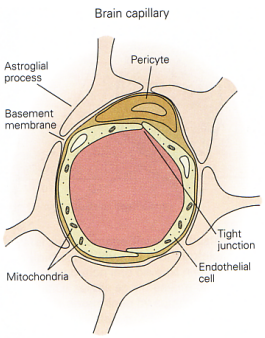
Blood Brain Barrier

Tight junctions and pericytes seal off brain capillaries.

Circumventricular organs are an exception.

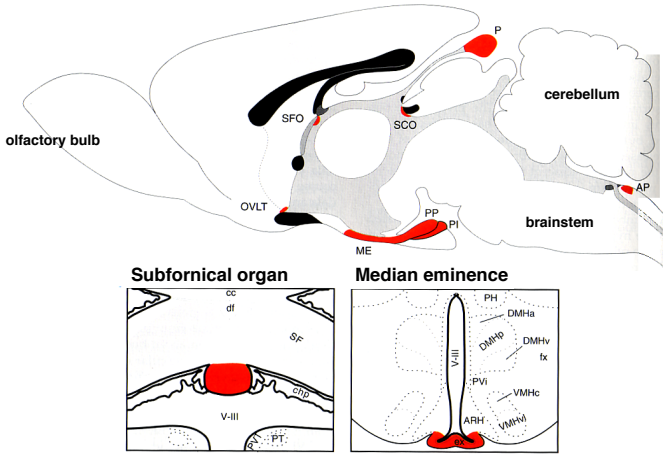


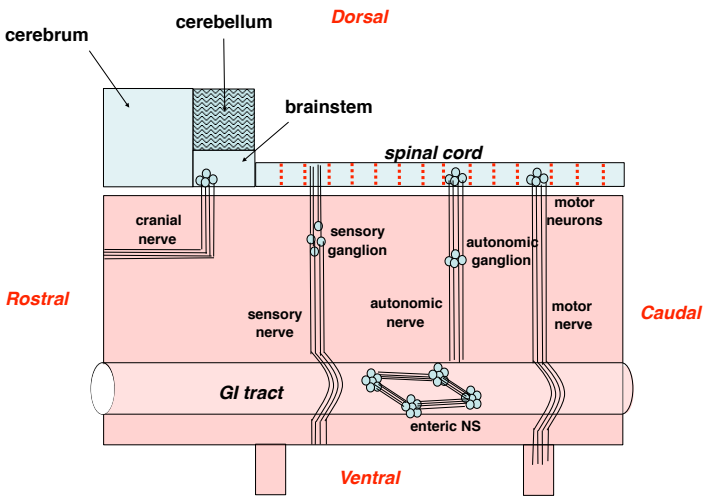
CVOs



Brain

Circumventricular Organs





Views of the Nervous System

1. **Anatomical**

   what is the location and connections of a brain structure; what are the effects of oblating that structure?

2. **Evolutionary/ Developmental**

   what are evolutionary and developmental origins of a structure, and how does that explain current function and connections?

3. **Functional Subsystems**

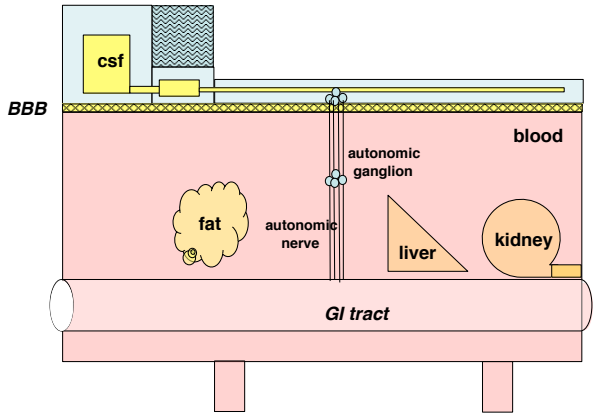
   what are functional and structural modules underlying a particular set of behavioral, autonomic, or cognitive functions? (e.g. somatic NS vs. autonomic NS).

4. **Pharmacological**

   what drugs have access to and influence on a particular structure?

Pharmacological View of Nervous System *in vivo*

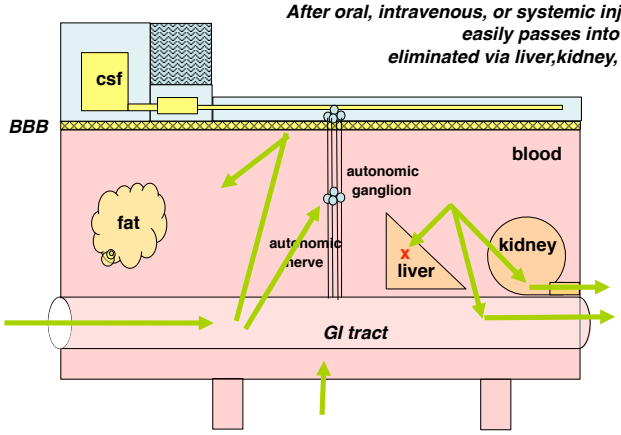
Several compartments: gut, blood, tissue, brain, CSF



Systemic Water-Soluble (Hydrophilic) Drug:

Acts on PNS, but excluded from CNS by BBB.

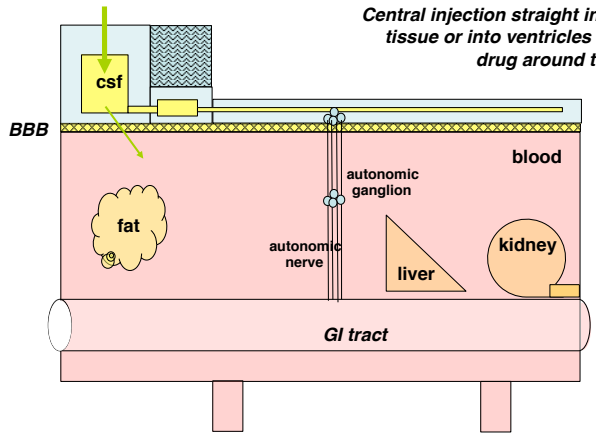
After oral, intravenous, or systemic injection, easily passes into blood; eliminated via liver,kidney, or gut.



Central Water-Soluble (Hydrophilic) Drug:

Acts on CNS, might act on PNS if enough leaks from CNS via CVOs.

Central injection straight into brain tissue or into ventricles gets the drug around the BBB.



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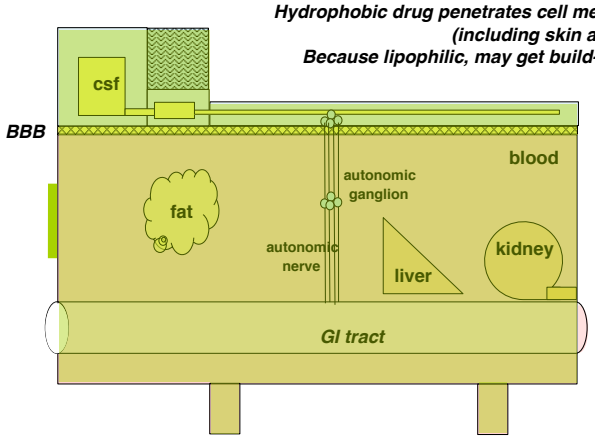
Acts on PNS and CNS.

Hydrophobic drug penetrates cell membranes (including skin and BBB). Because lipophilic, may get build-up in fat.



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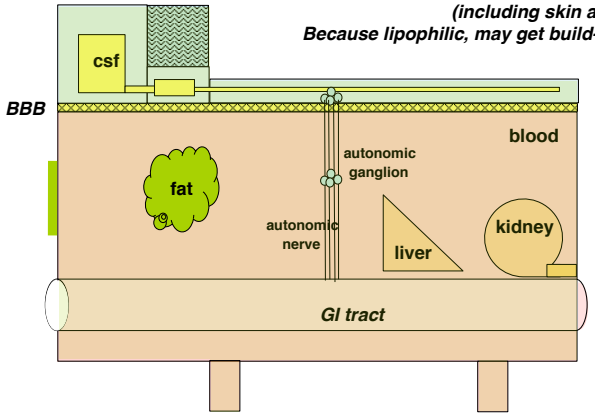

Drug Properties

Large, hydrophilic molecules cannot cross the blood brain barrier. So for a peripheral chemical to affect the brain, the chemical must be able to do one of the following:

1. **Indirectly affect the brain by acting on peripheral nerves outside the BBB that send a neural signal to the brain**

   cholecystokinin, a peptide that decreases feeding by sending a satiety signal via the vagus nerve to the brain.

2. **Be carried across the BBB by a transporter on the walls of brain capillaries, or affect the brain capillaries directly**

   L-DOPA for Parkinson's disease is transported as an amino acid;

   ibuprofen acts on endothelial cells of BBB to affect prostaglandin release into brain.

3. **Be able to pass directly through the cell membranes of the BBB.**

   steroids used to control brain inflammation;
   benzodiazepines and barbituates.

Levels of analysis of a neuron

Where is the cell body of the neuron located?

Where is the dendritic field (inputs) of the neuron?

Where does the neuron send its axon (outputs)?

What functional system is the neuron part of?

What types of drugs can access the neuron?

What input does the neuron get, and what receptors are present postsynaptically?

What transmitters does the neuron release presynaptically?

What are the intracellular signaling and transcriptional networks that modulate long-term function of the neuron?