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2

The hierarchy and the logic of nervous system evolution

Evolutionary approach
Evolution is not revolution

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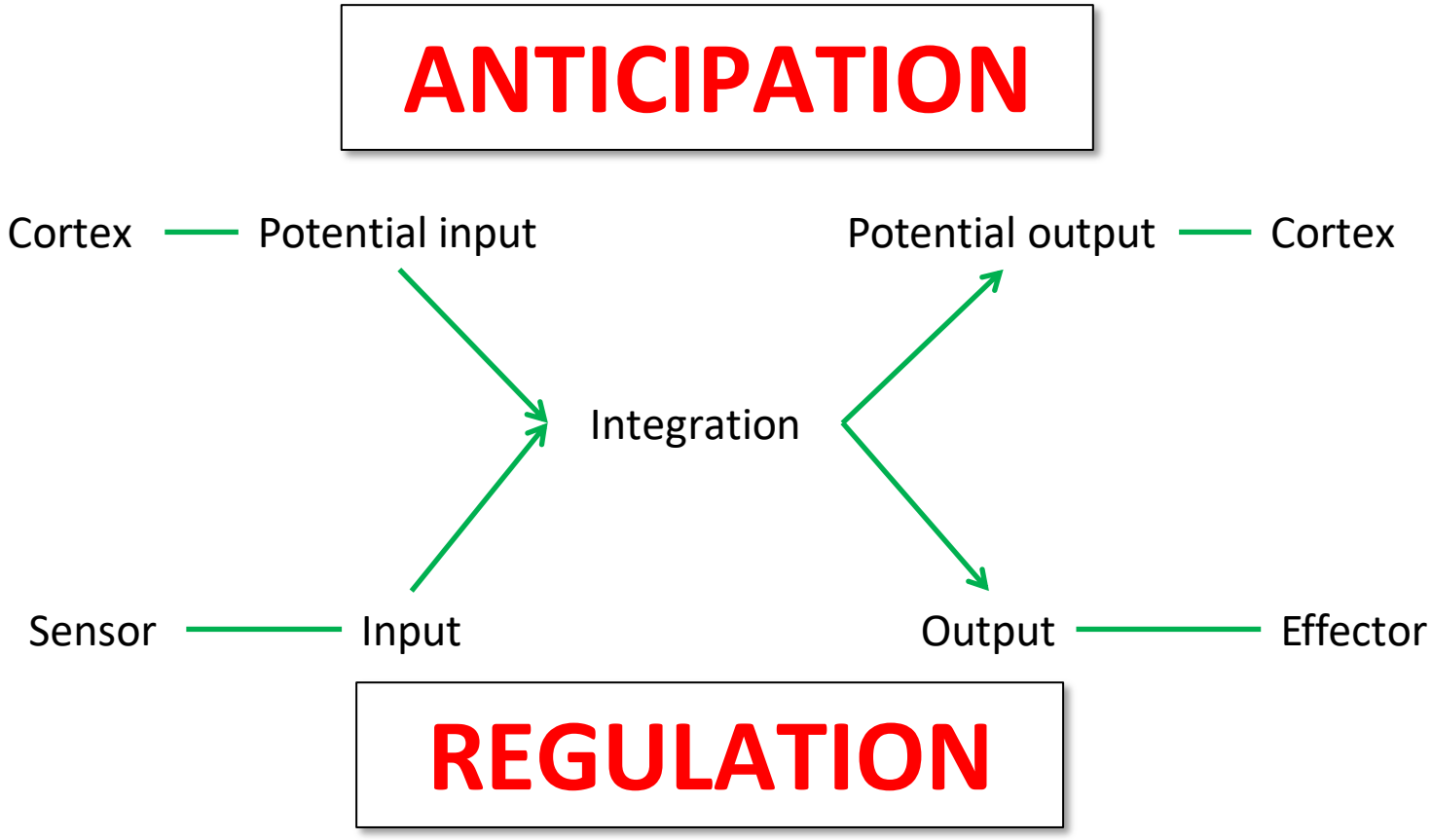
The role of nervous system



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The logic of evolution of the nervous system

Input → Integration → Output

Four basic types of tissue

- ✓ **Epithelial**
- ✓ **Connective**
- ✓ **Muscular**
- ✓ **Nervous**

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The logic of evolution of the nervous system

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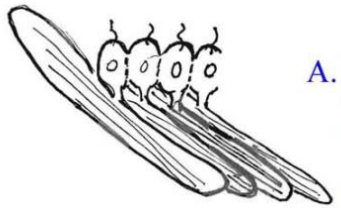

A. Myoepithelium:
contractile epithelial cells
responding to stimulation and
interconnected by electrical
synapses (gap junctions)

Gerald Schneider. *9.14 Brain Structure and Its Origins, Spring 2014*. (Massachusetts Institute of Technology: MIT OpenCourseWare), http://ocw.mit.edu (Accessed). License:Creative Commons BY-NC-SA

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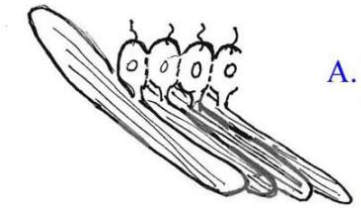

A. Myoepithelium: contractile epithelial cells responding to stimulation and interconnected by electrical synapses (gap junctions)

B. Protomyocytes separate from sensory epithelium, all connected by electrical synapses

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The logic of evolution of the nervous system

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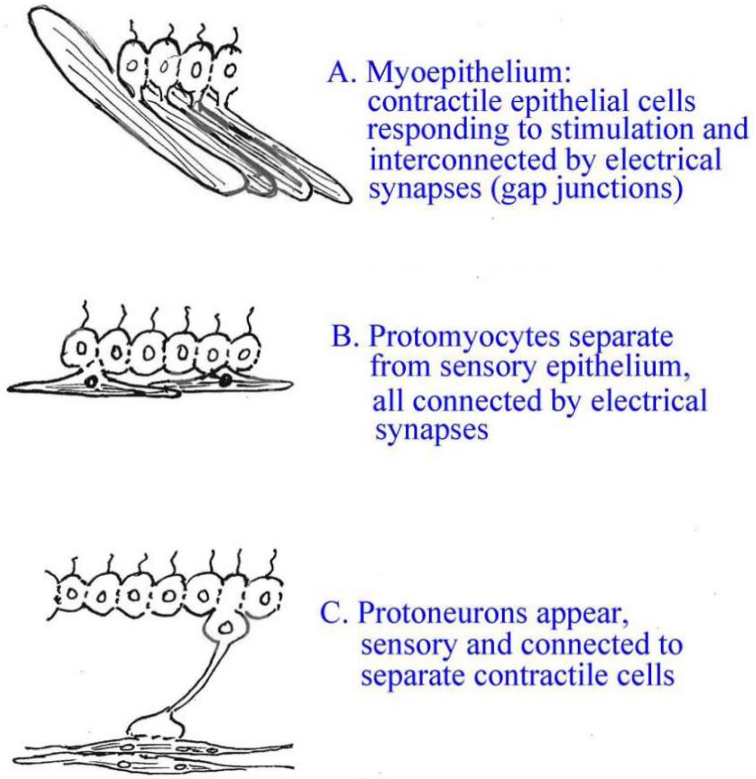

Gerald Schneider. *9.14 Brain Structure and Its Origins, Spring 2014*. (Massachusetts Institute of Technology: MIT OpenCourseWare), http://ocw.mit.edu (Accessed). License:Creative Commons BY-NC-SA

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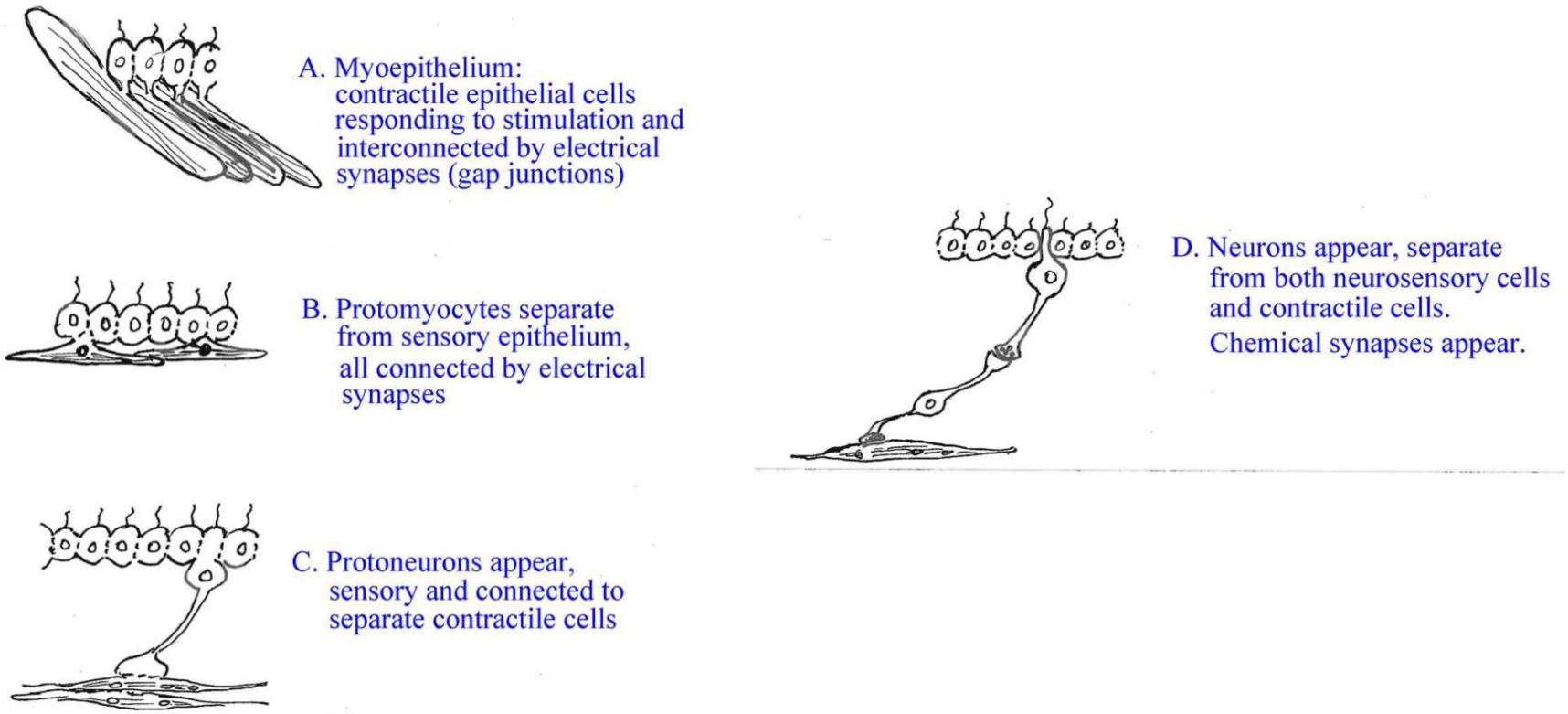

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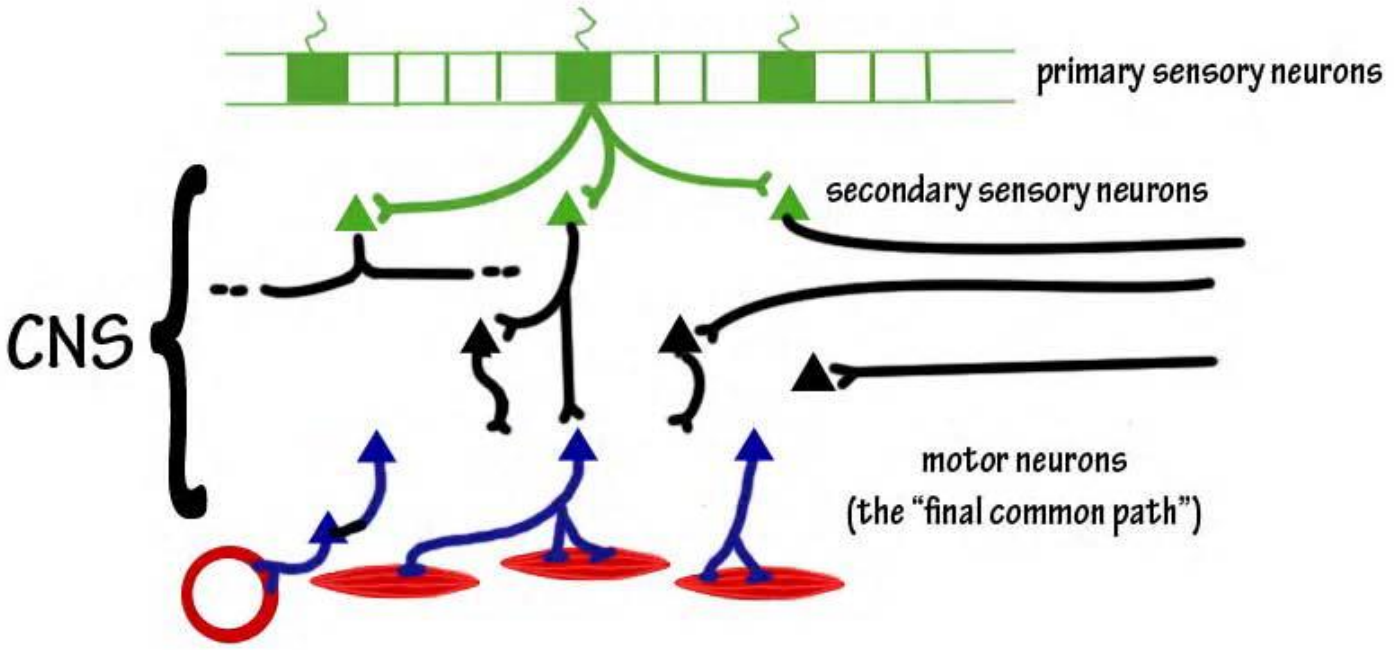
The logic of evolution of the nervous system



Input

Integration

Output

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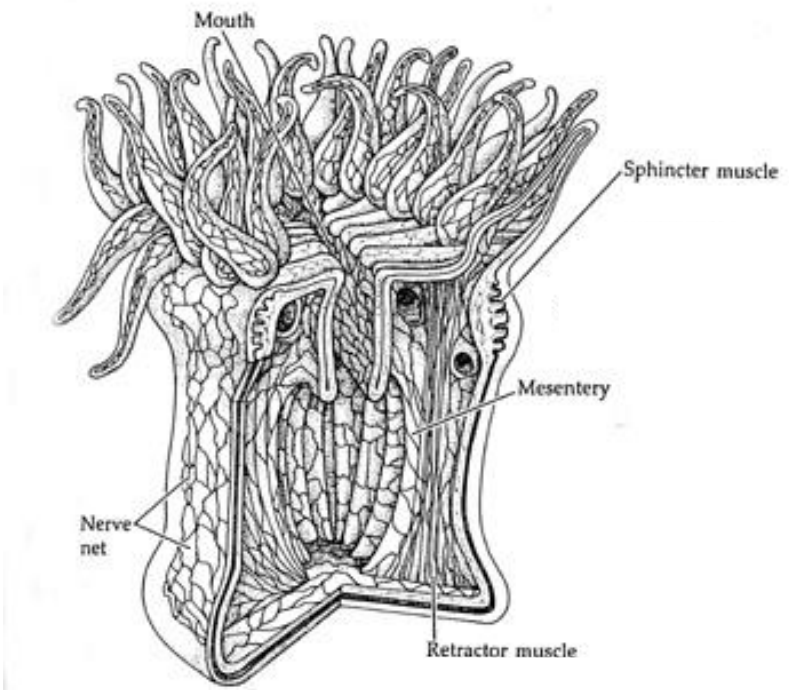
The logic of evolution of the nervous system

- Polyp
  - Reticular NS
  - Nonspecific reaction on irritation



http://xavierinterestingscience.weebly.com/cnidaria.html

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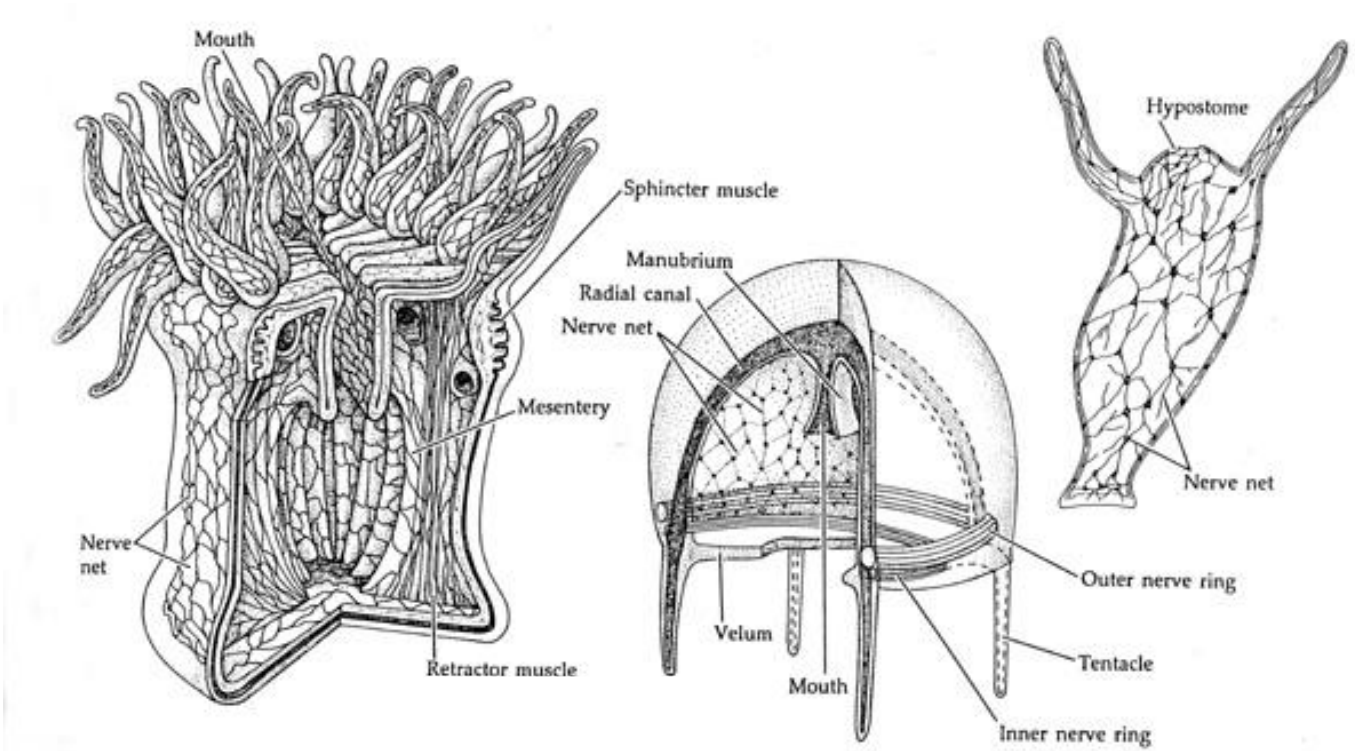
The logic of evolution of the nervous system

- Polyp
  - Reticular NS
  - Nonspecific reaction on irritation
- Jellyfish
  - Around propulsion part is nervous system into the ring
  - Coordinated contraction – coordinated movement



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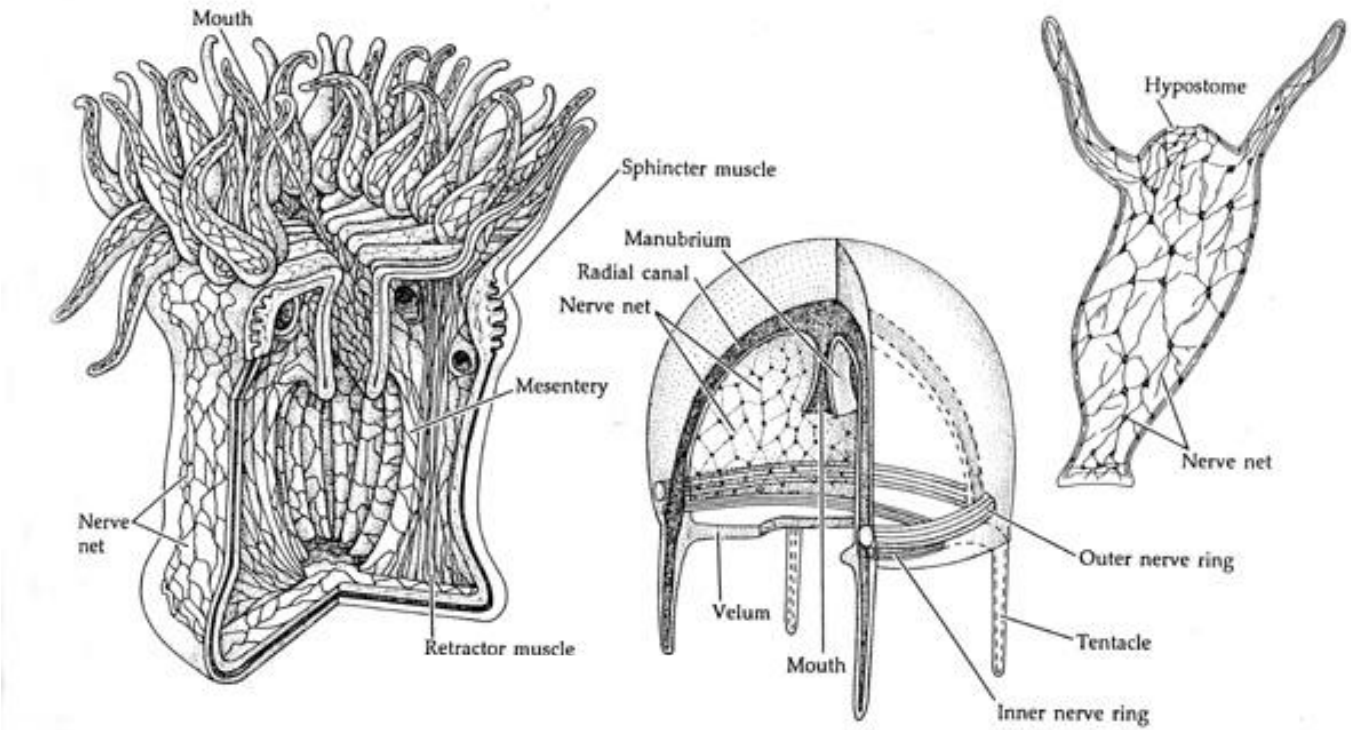
FOTORECEPTION



http://xavierinterestingscience.weebly.com/cnidaria.html

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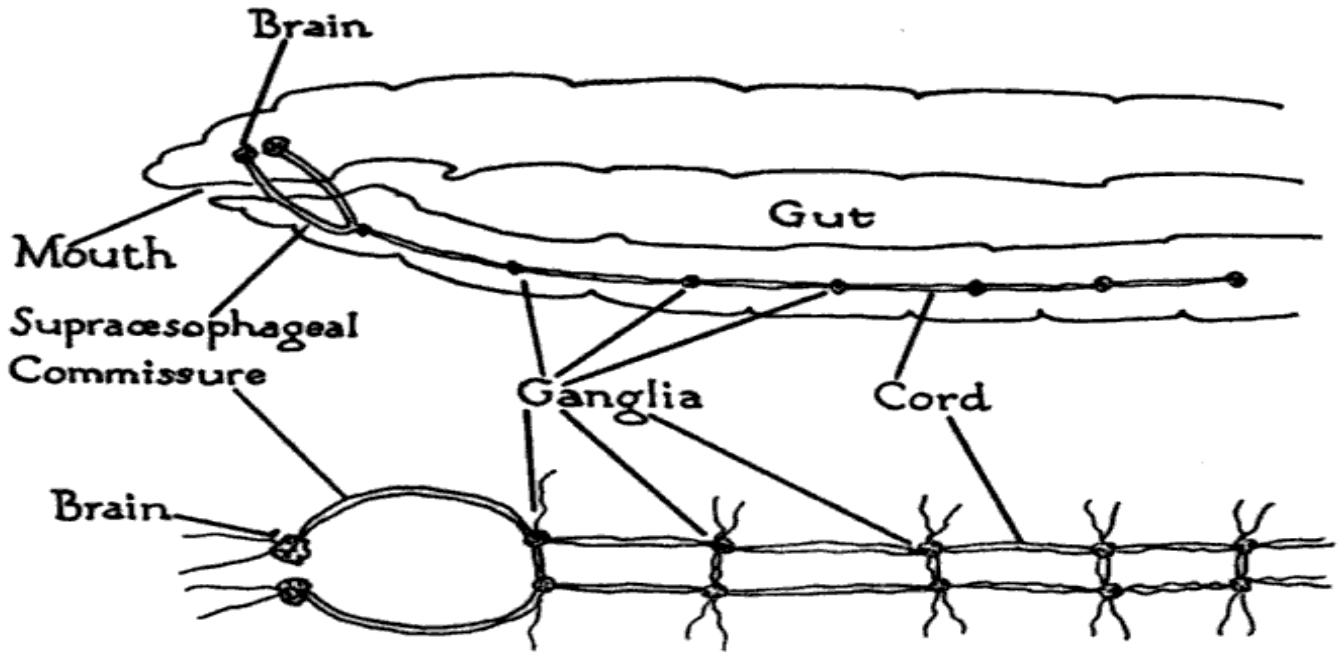
The logic of evolution of the nervous system

- Worms
  - Segmented nervous system
  - Left – right coordination
  - Ganglia
  - „Brain“ ganglion – head – forward locomotion – food intake



https://en.wikipedia.org/wiki/Earthworm

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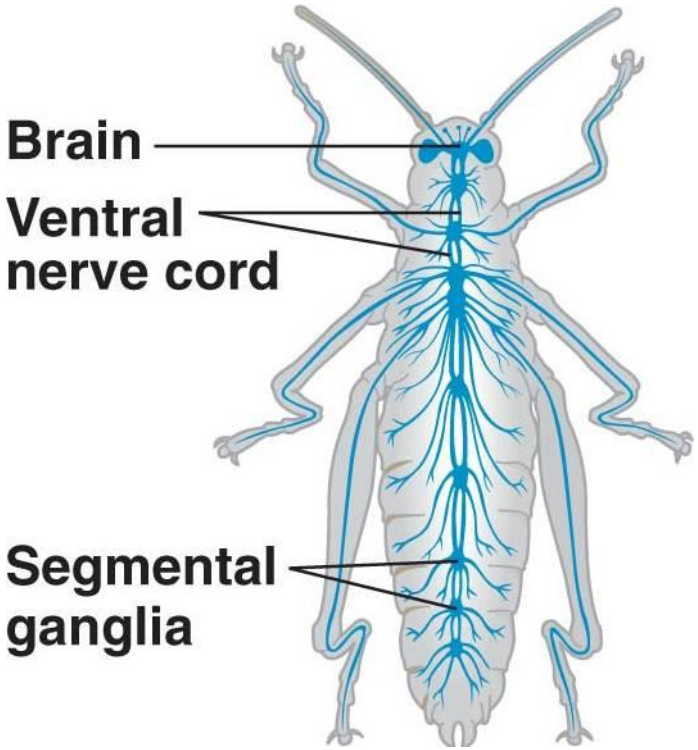
The logic of evolution of the nervous system

- Insect
  - „Sophisticated“ NS
  - Coordinated movement
  - „Developed“ senses
  - Communication skills (bee)
  - Social structures



http://bilingualbiology10.blogspot.cz/2013/08/topic-11b-arthropods-izeltlabuak.html

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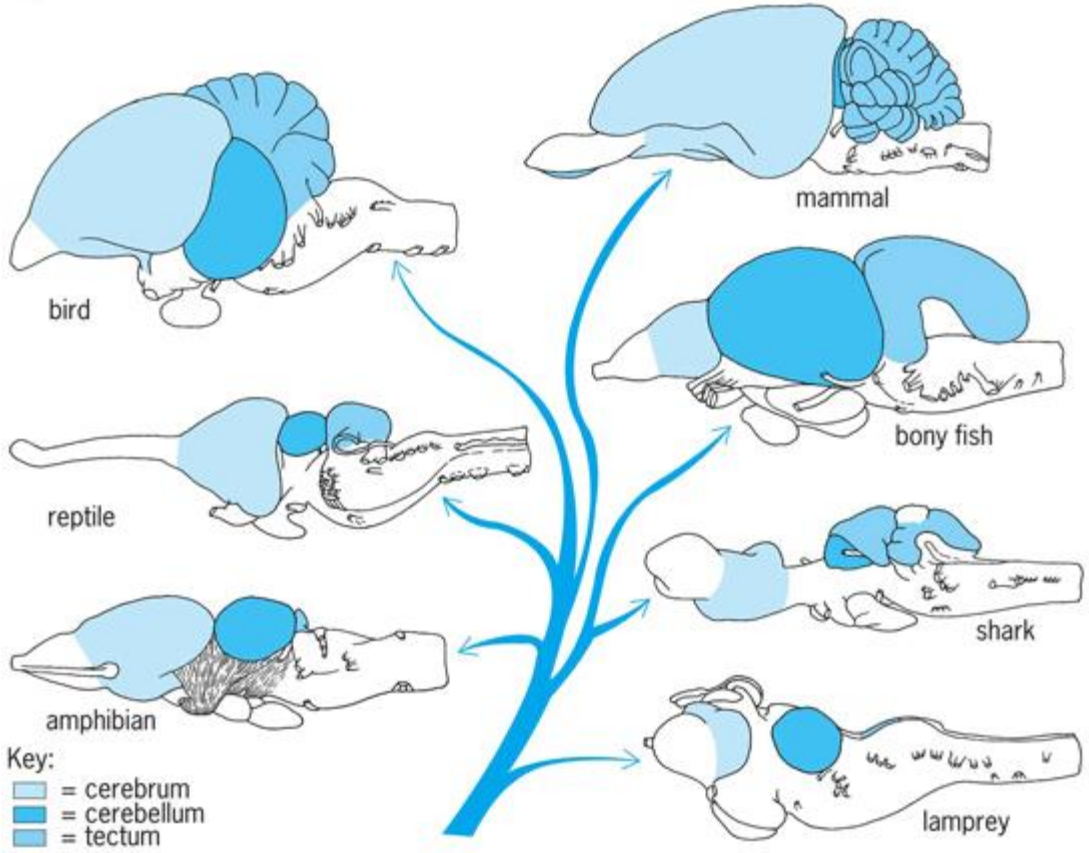
The logic of evolution of the nervous system

- Vertebrates
  - ➢ Cartilaginous or bony protection of CNS
  - ➢ Real brain
  - ➢ Very sophisticated NS
    - Coordinated movement
    - Senses
    - Social structures
    - Intelligence
  - ✓ Fishes (intelligence)
  - ✓ Amphibians
  - ✓ Reptiles (emotions)
  - ✓ Birds and mammalians (the top of evolution)



Northcutt RG, Noback CR, Kallen B. Nervous system (vertebrate). *Access Science* [Internet]. 2020 [cited 2021 Sep 17]; Available from: https://www.accessscience.com/content/nervous-system-vertebrate/449300

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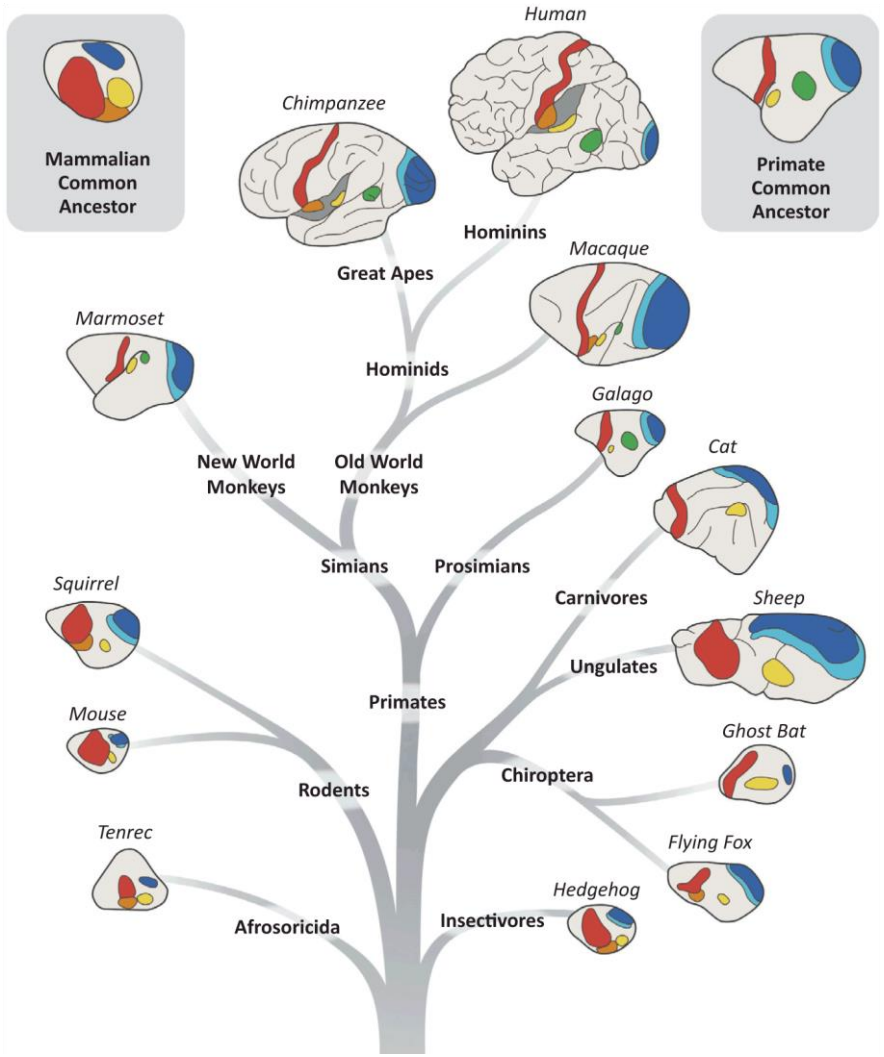
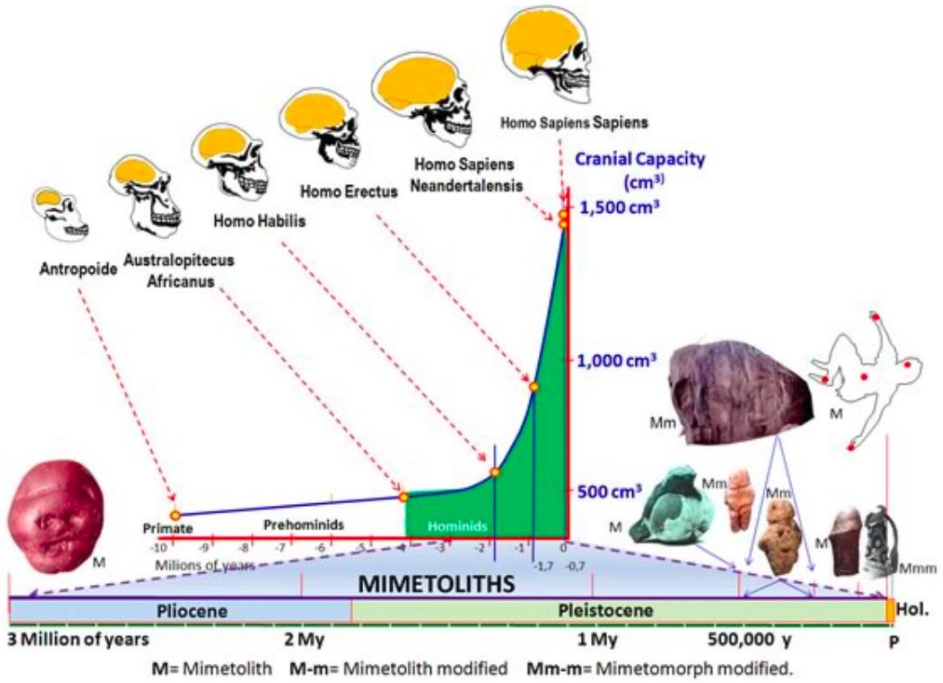
The logic of evolution of the nervous system



http://scienceblogs.com/pharyngula/2013/12/27/frugal-to-the-point-of-vacuity/

Evolution is shaped by environment



http://www.rupestreweb.info/mimesis.html

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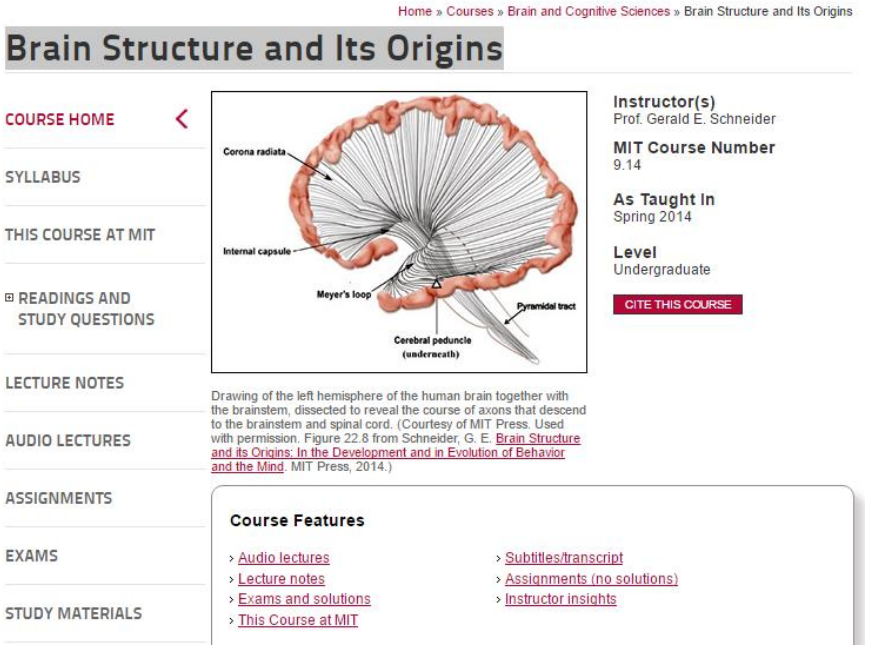
Basics of behavior enabling survival

- **Multipurpose movements**
  - The most basic actions of individual organisms
  - ***Locomotion***: to approach or to avoid something
  - ***Orienting***: towards or away from something
  - ***Exploring/foraging/seeking*** (includes the first two plus motivation)



MIT - Brain Structure and Its Origins

http://ocw.mit.edu/courses/brain-and-cognitive-sciences/9-14-brain-structure-and-its-origins-spring-2014/#

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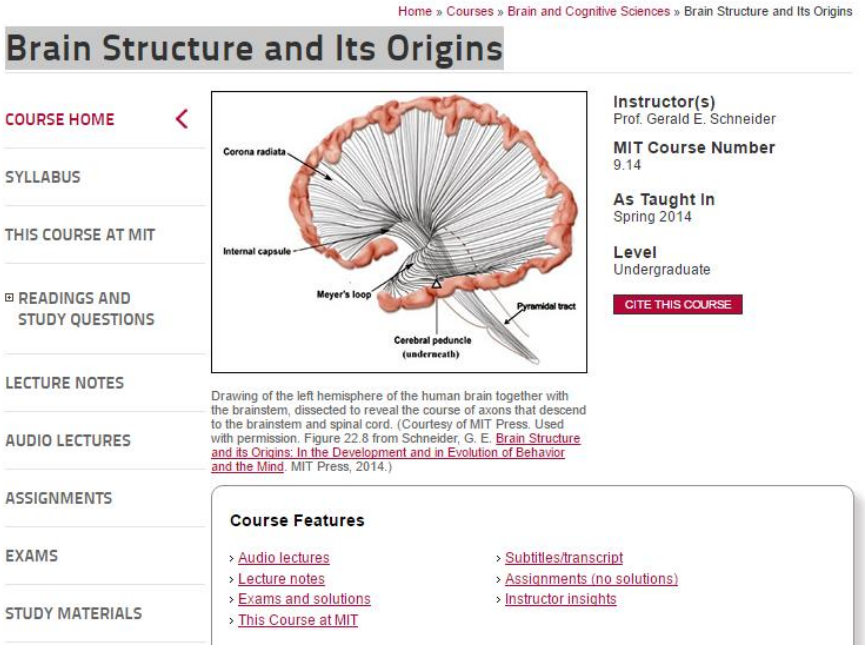
  - respiration, temperature regulation, postural reflexes



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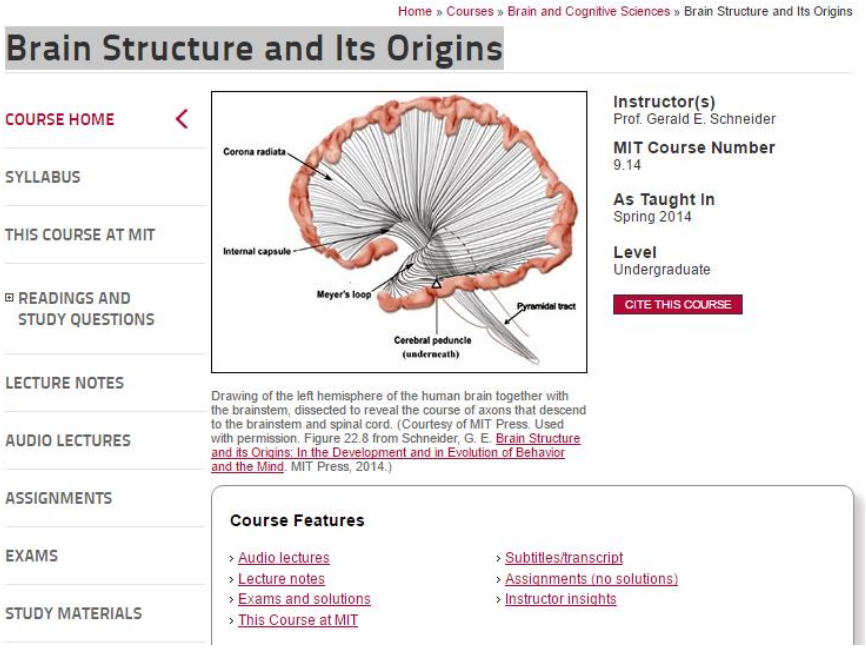

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  - ➢ ***Locomotion***: to approach or
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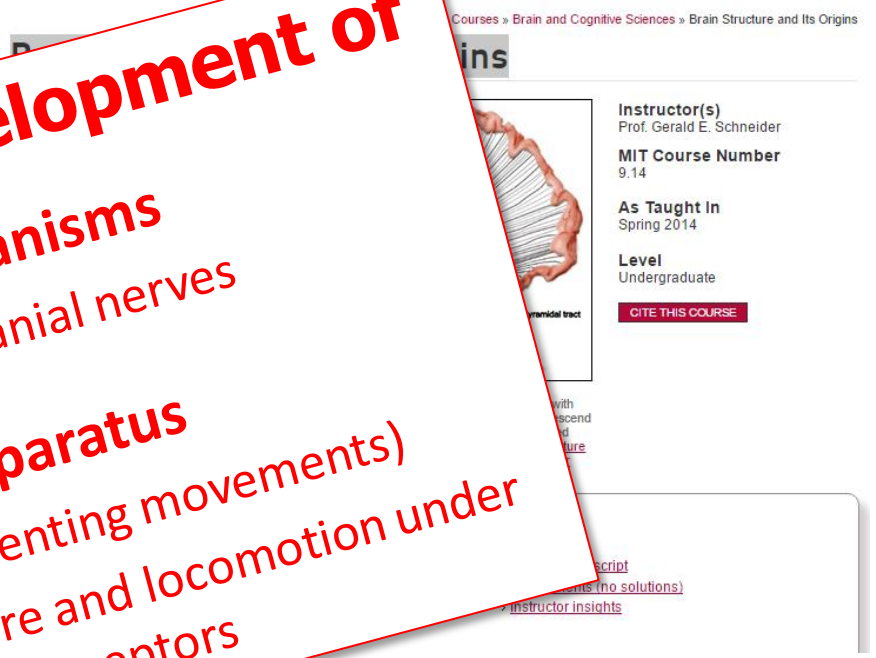
  - ➢ ***Explori***
    plus mo
- **Background**
  - respiratio
    reflexes
- **Motivation**

Locomotion influenced development of

- **Sensory analyzing mechanisms**
  - Connected to inputs from cranial nerves
- **Associated motor apparatus**
  - For directing the receptors (orienting movements)
  - For controlling alterations in posture and locomotion under guidance from these receptors



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Evolution of the brain

- Neural tube
- Locomotion
- Rostral receptors

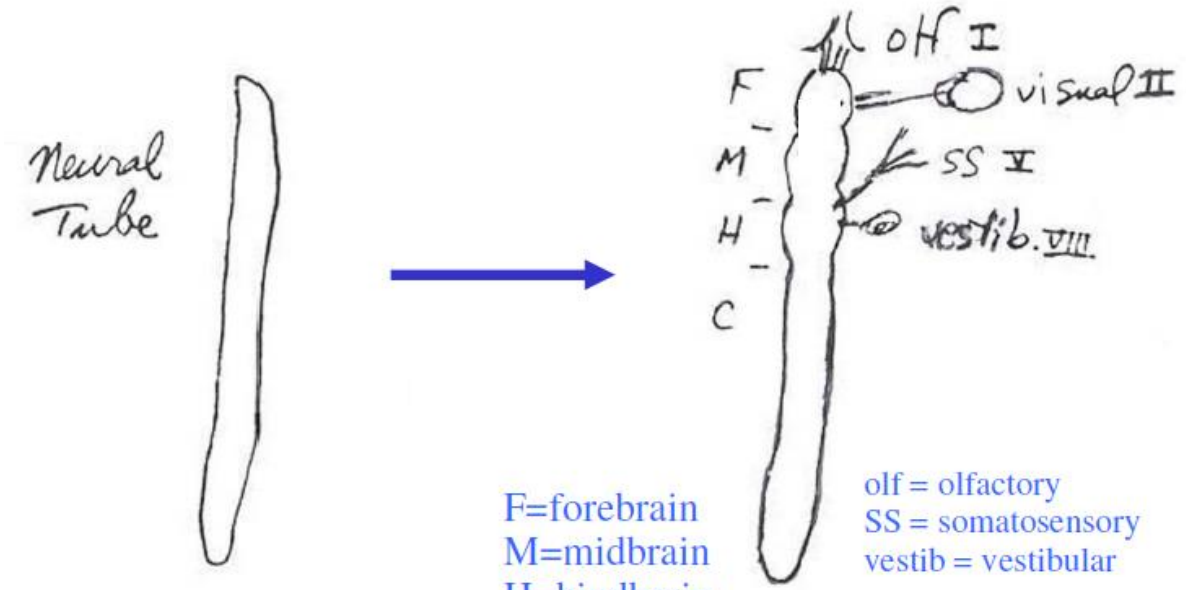

Fig. 4-1

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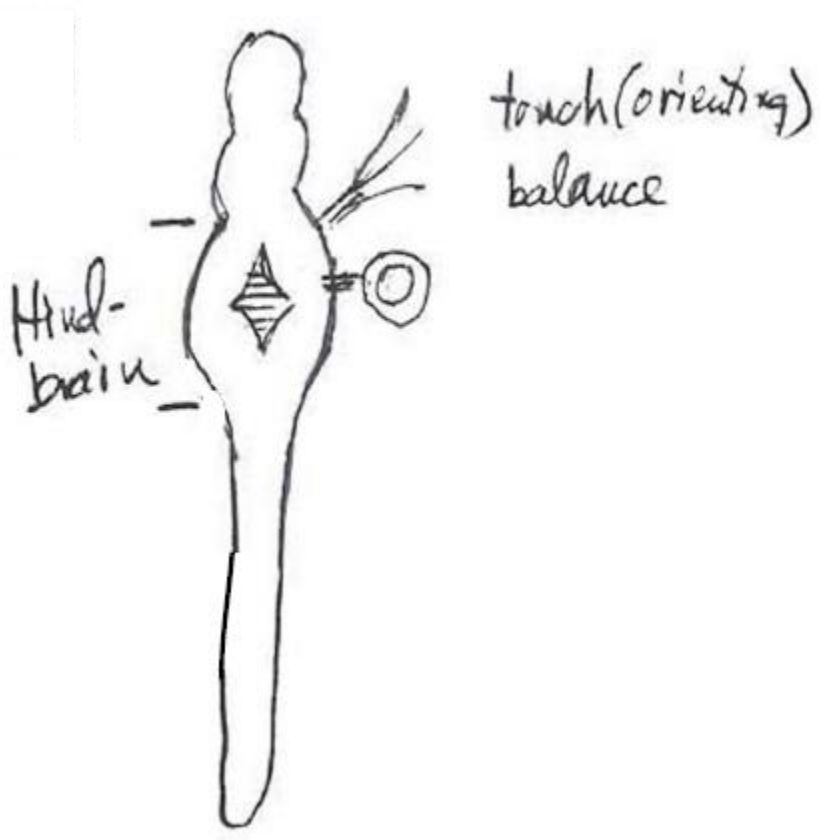
Evolution of the brain

- **Expansion of hindbrain**

  (Rhombencefalon - Medula oblongata, pons Varoli, cerebellum)

- Input
  - Information form head sensors
- Output
  - Motor system

    (Fixed action pattern - reflex/instinct behavior)



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Evolution of the brain

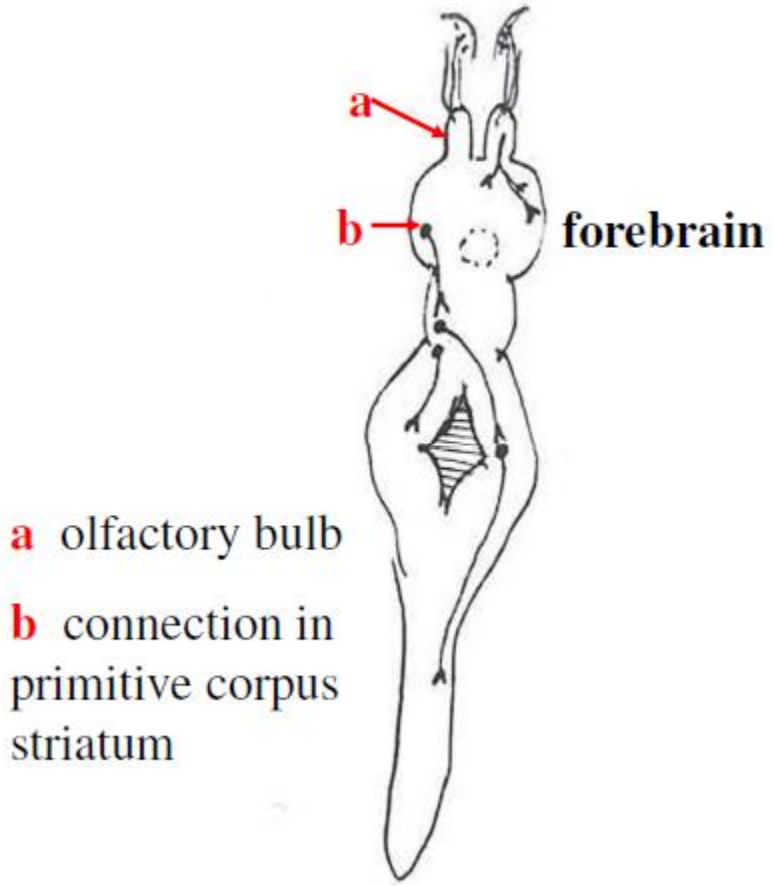
- **Expansoin of forebrain 1**

  (Prosencephalon - diencephalon, telencephalon)

  (simultaneously with hindbrain)

- Input
  - Olfaction (Approach/avoidance)
- Output
  - Motor system

    (via corpus striatum)



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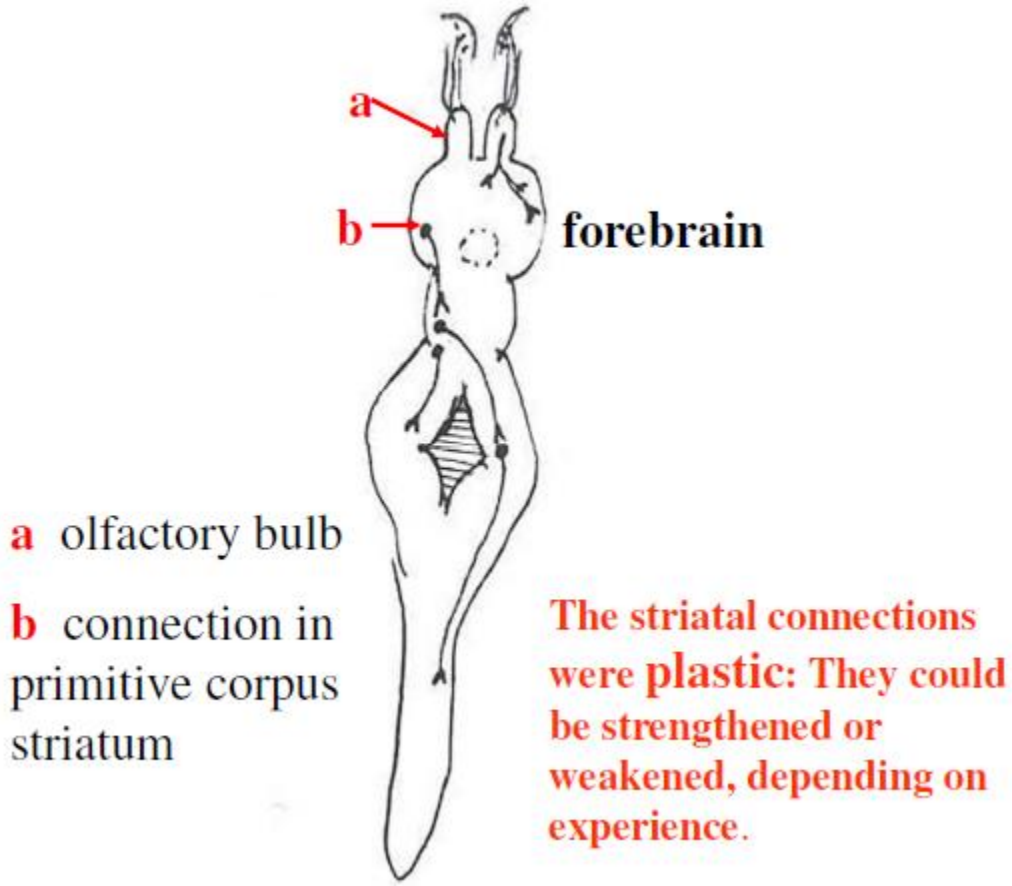

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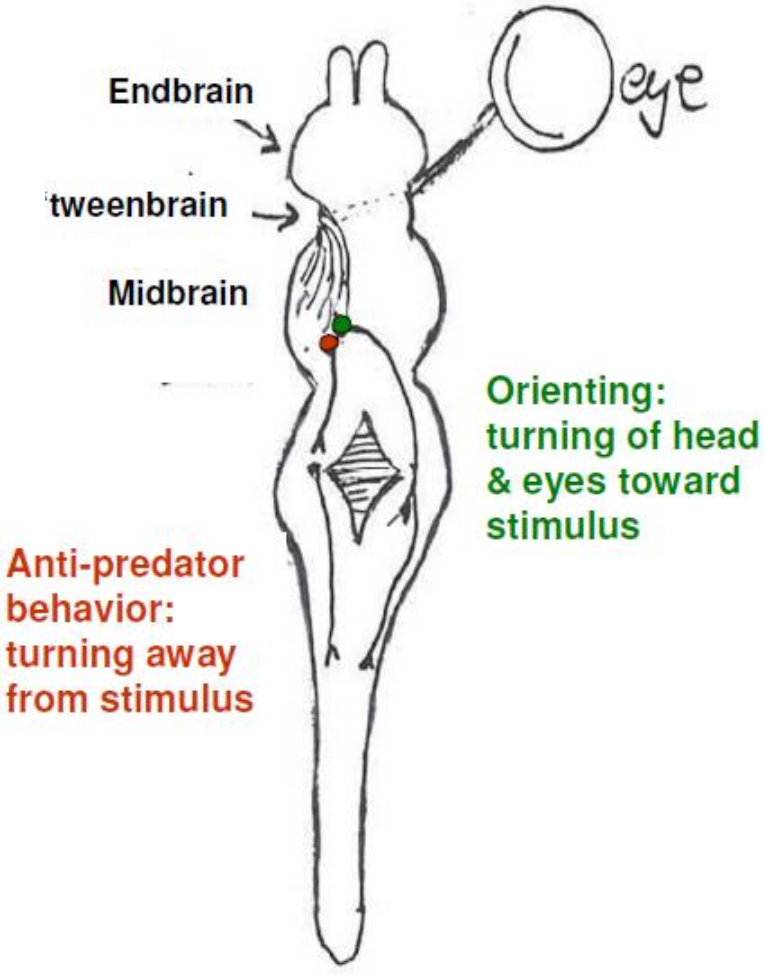
Evolution of the brain

- **Expansion of midbrain**
- Input
  - Vision, audition (distant senses)
- Output
  - Motor system

    (Approach – contralateral m.)

    (Avoidance – ipsilateral m.)
- Advantage
  - Speed
  - Acuity



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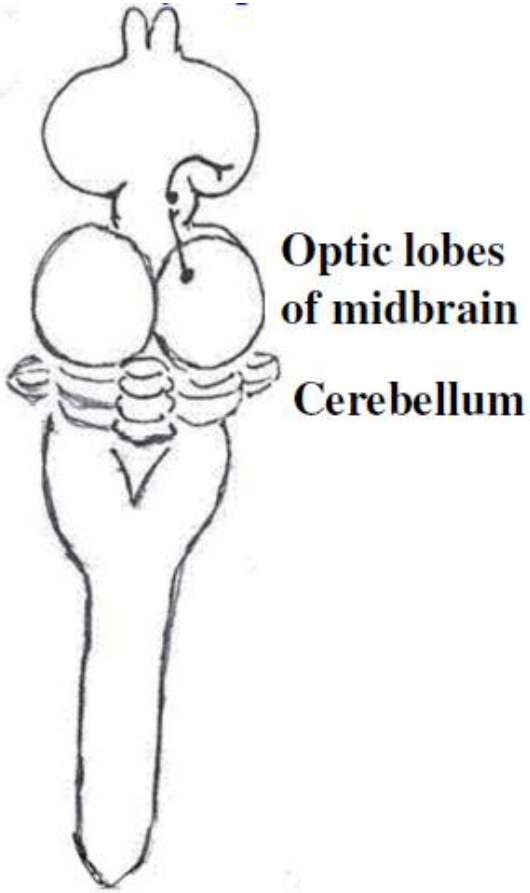
Evolution of the brain

- **Expansoin of forebrain 2**

  (Prosencephalon - diencephalon, telencephalon)

- Input
  - Nonolfactory systems connected to forebrain
  - Mainly vision and hearing
- Advantage
  - Plastic connections of forebrain
- Thalamus
  - Gating

    (Corpus striatum and cortex)



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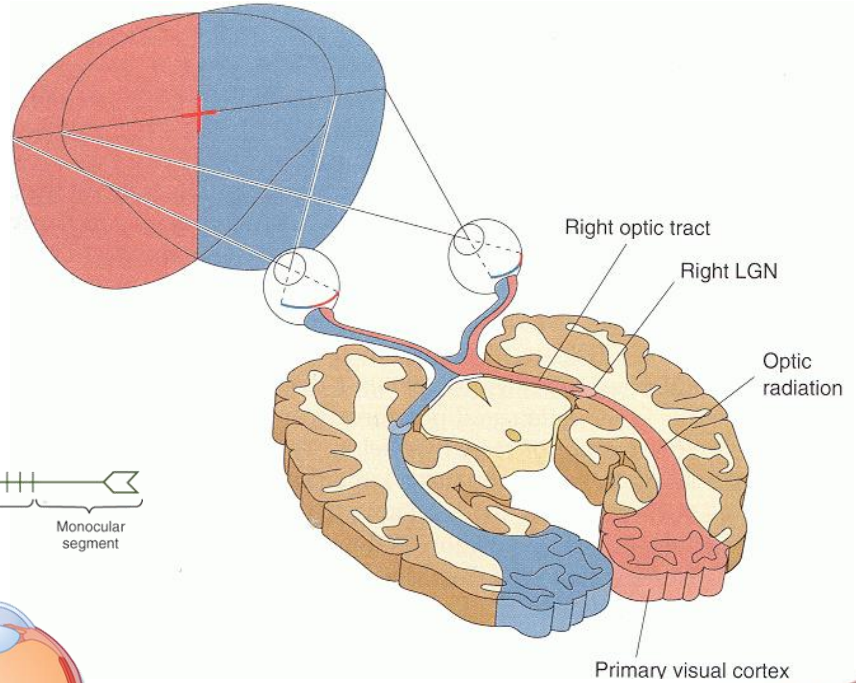
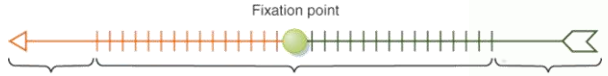
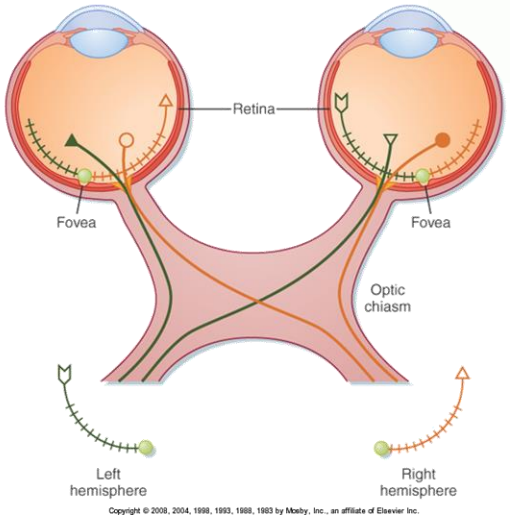
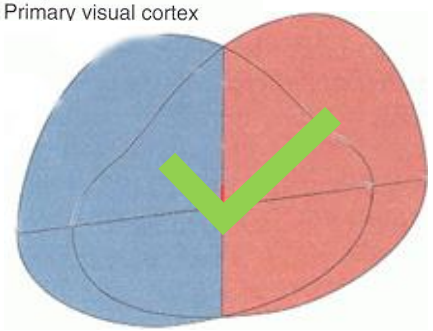
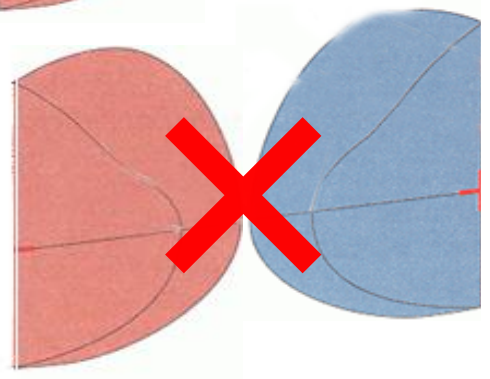
http://fourier.eng.hmc.edu/e180/lectures/v1/node2.html

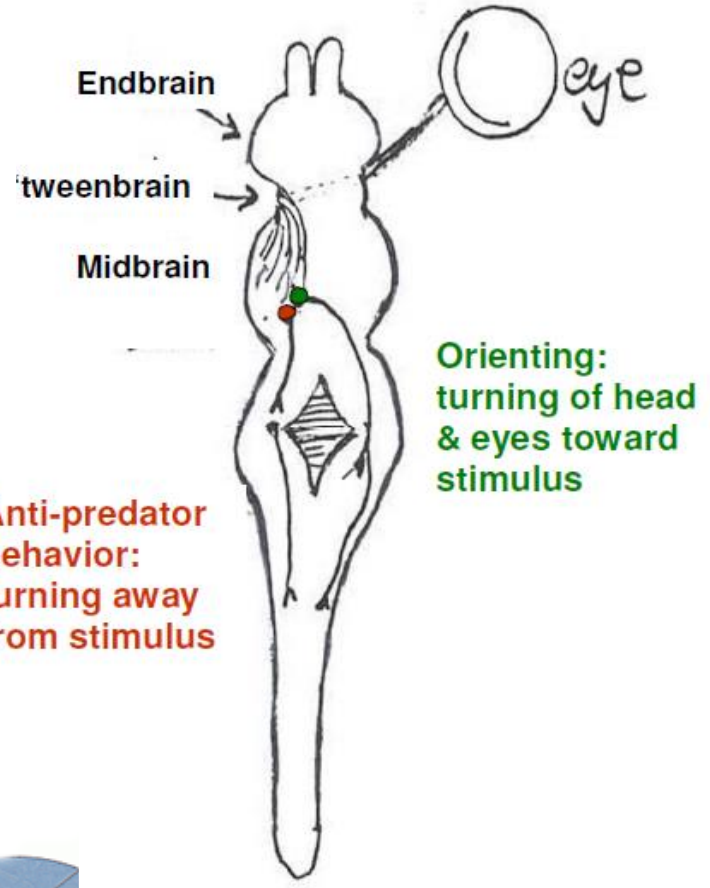












http://www.slideshare.net/CsillaEgri/presentations

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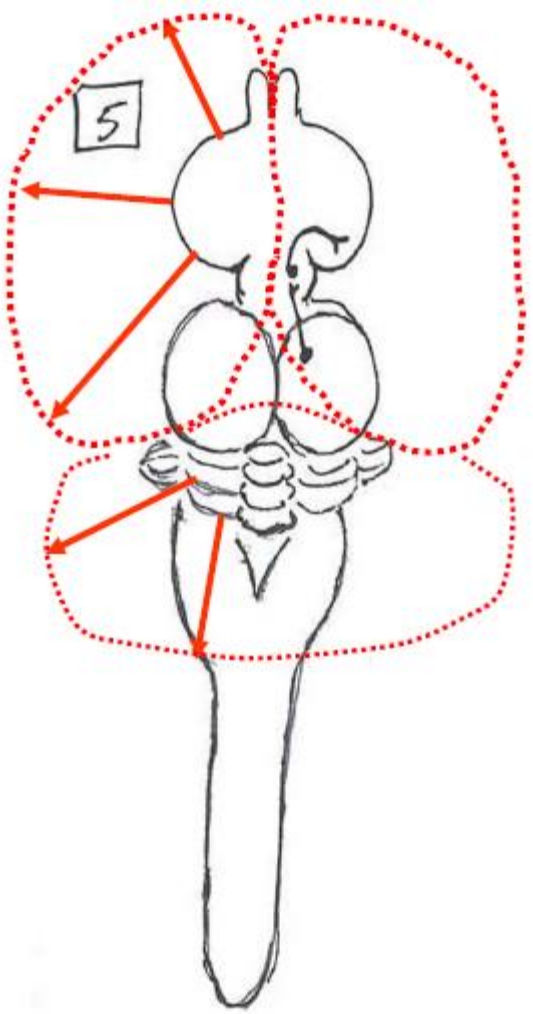
Evolution of the brain

- **Expansoin of forebrain 3**
- Neocortical expansion
- Simultaneous expansion of
  - Neostiratum
  - Neocerebellum
- Advantage
  - „High resolution“ information processing
  - Anticipation



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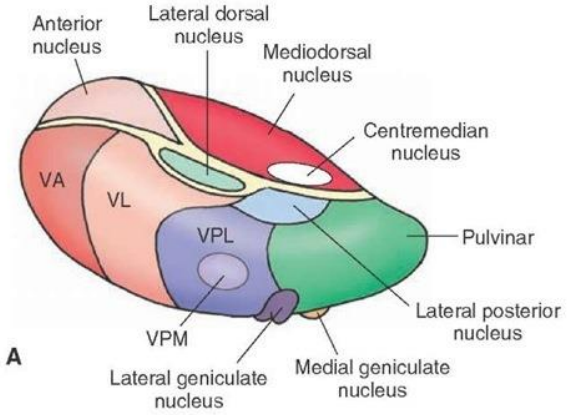
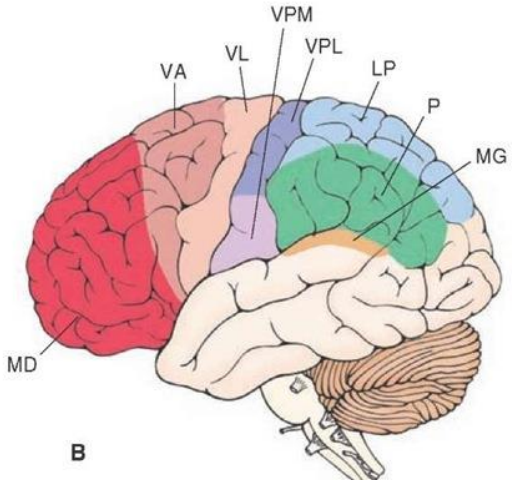
Thalmus and neocortex

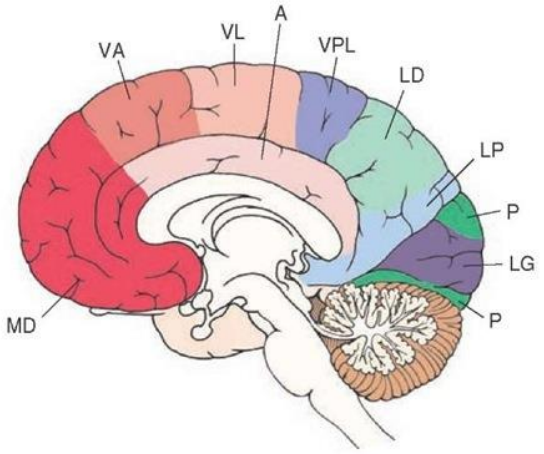
Gating

- Thalamic nuclei
  - Nonspecific
  - Specific

- Reciprocal connections between thalamus and neocortex







http://what-when-how.com/neuroscience/the-thalamus-and-cerebral-cortex-integrative-systems-part-2/

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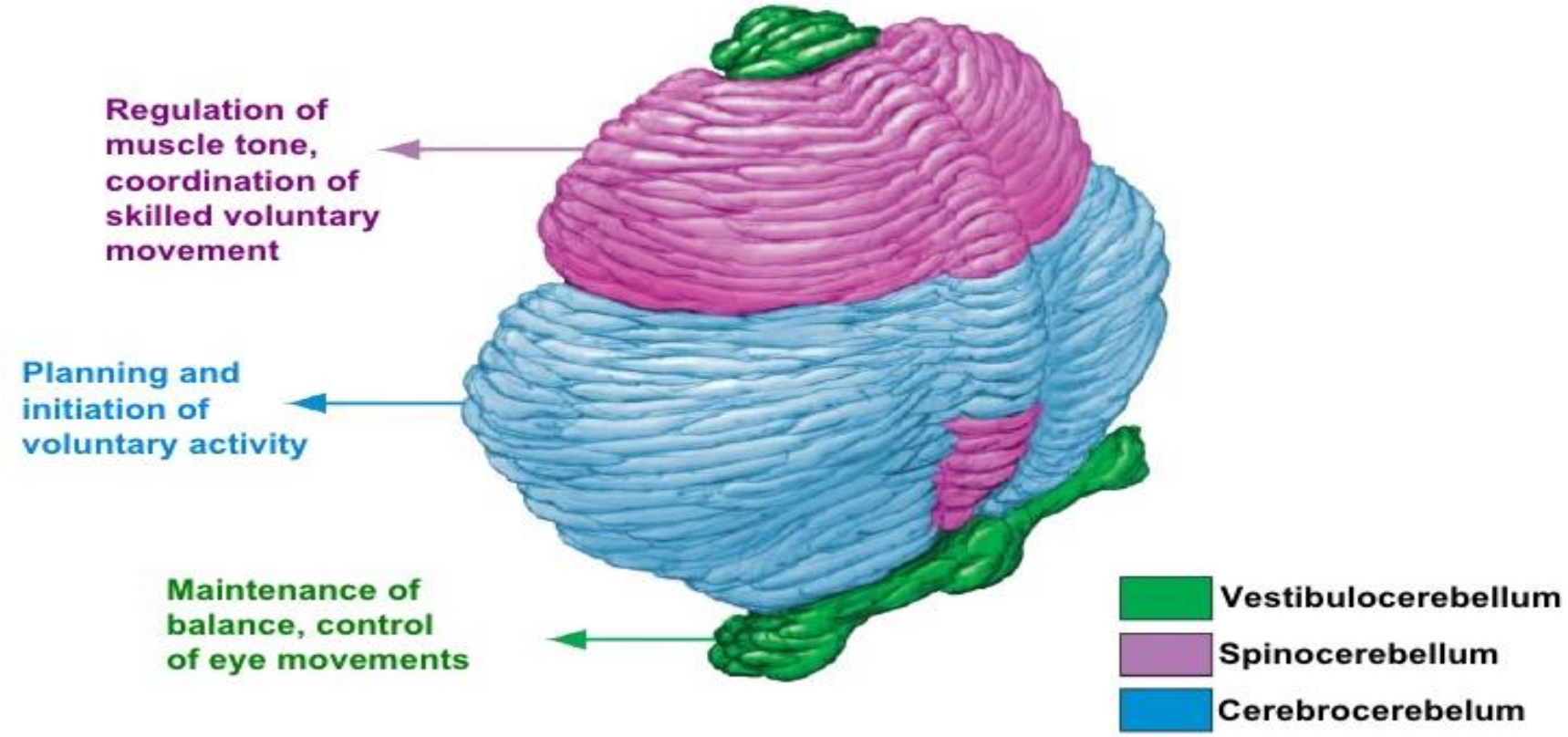
Cerebellum

Coordination



http://www.slideshare.net/HarshshaH103/cerebellum-its-function-and-releveance-in-psychiatry

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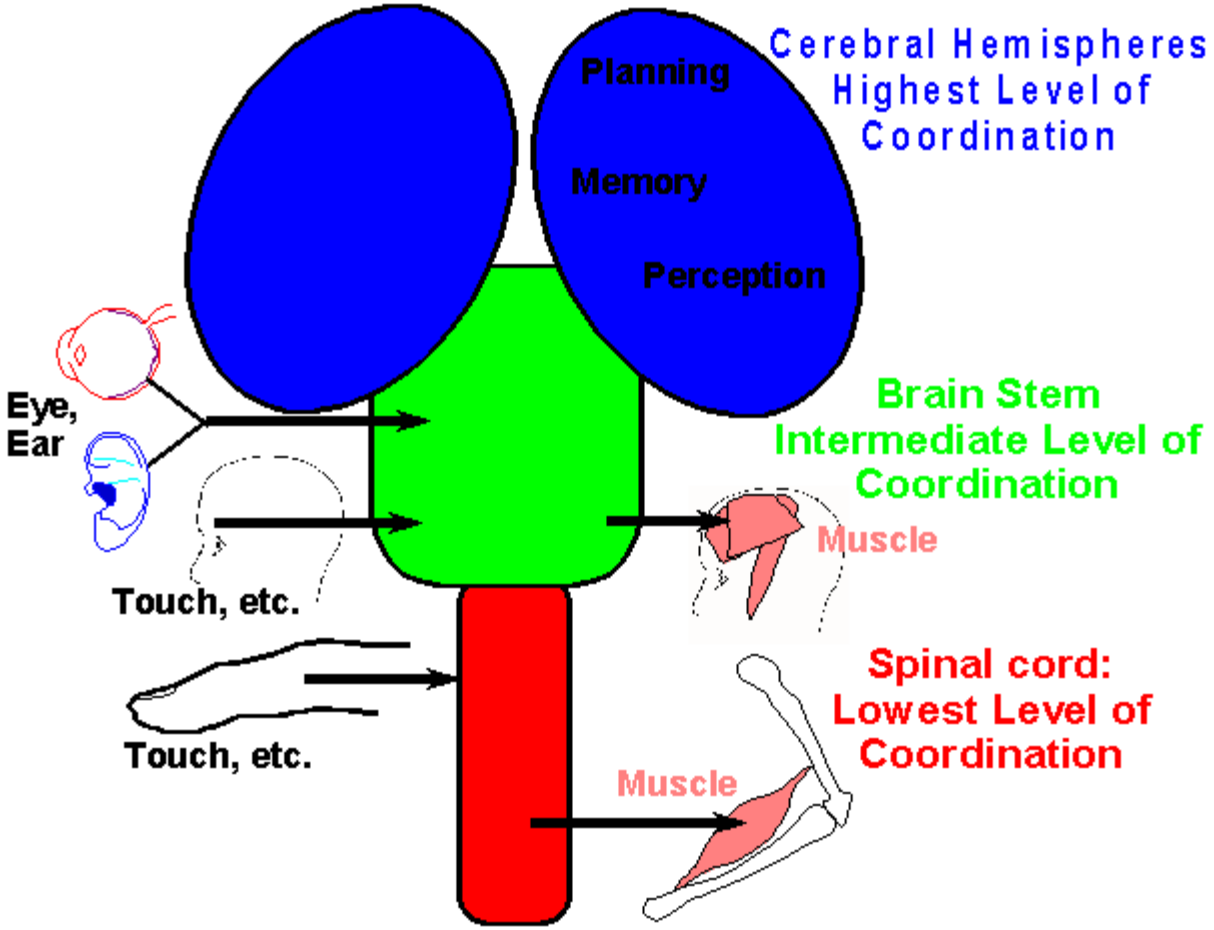
Hierarchy of central nervous system



http://www.indiana.edu/~p1013447/dictionary/cns.htm

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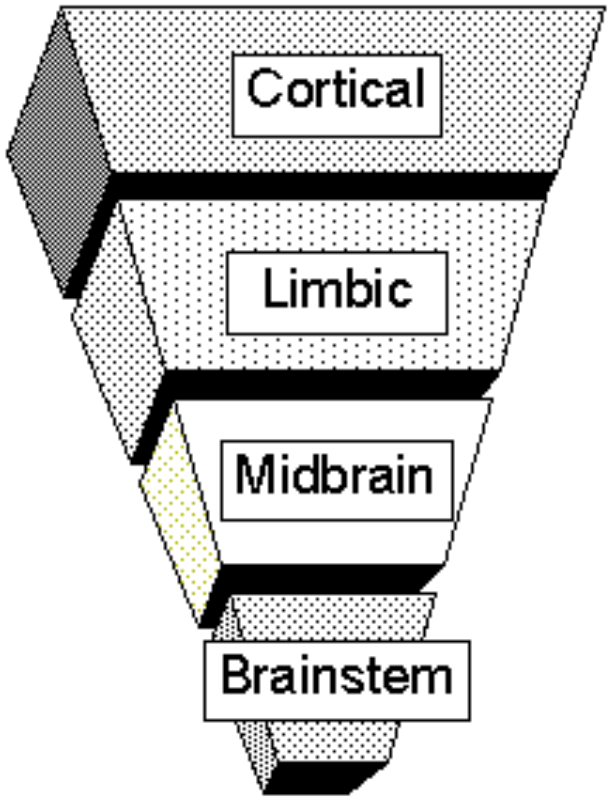

Abstract Thought
Concrete Thought
Affiliation
Attachment
Sexual Behavior
Emotional Reactivity
Motor Regulation
"Arousal"
Appetite/Satiety
Sleep
Blood Pressure
Heart Rate
Body Temperature

https://rajugurusamy.files.wordpress.com/2007/11/memories1.gif?w=497

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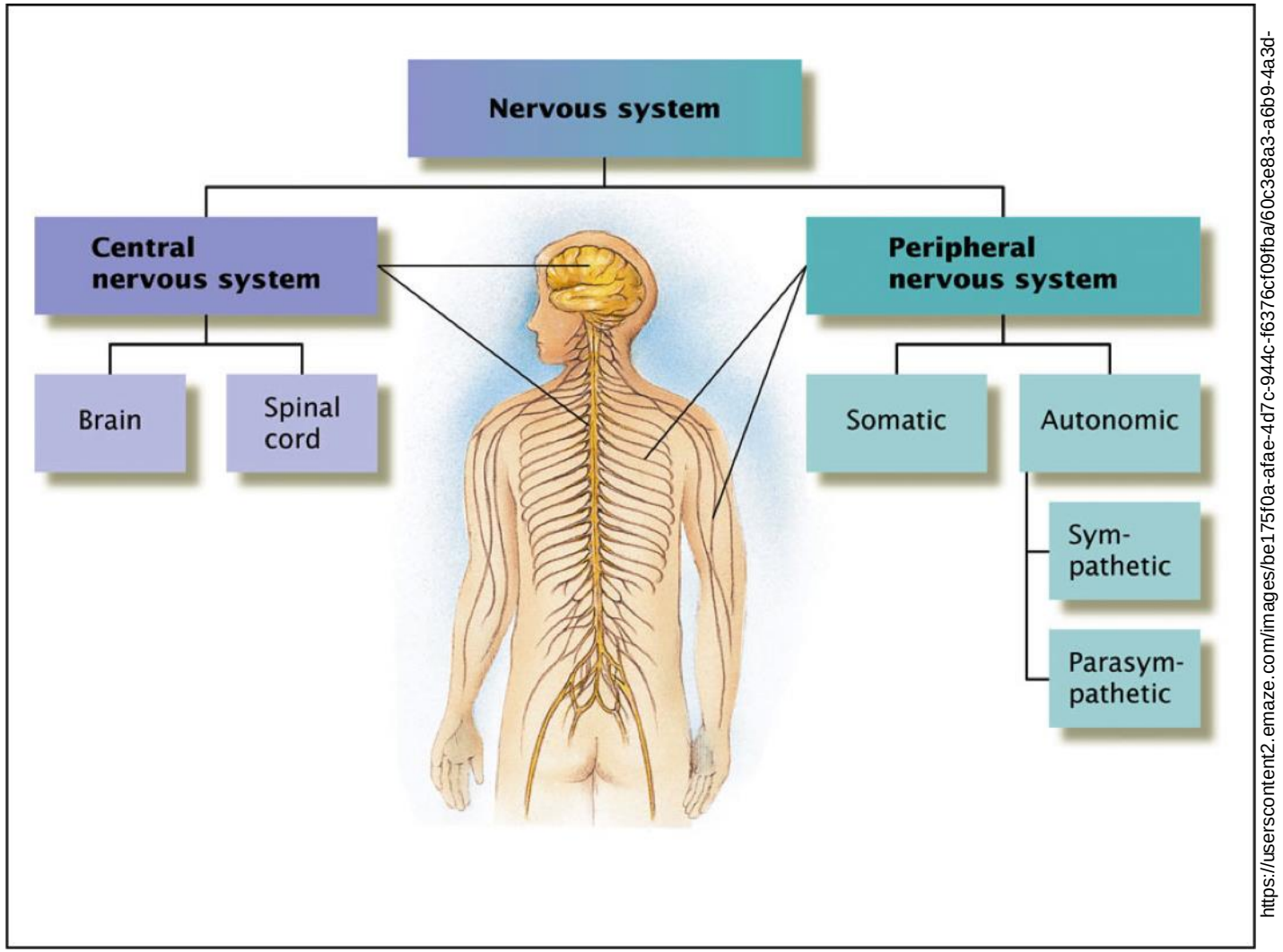
Hierarchy of nervous system



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