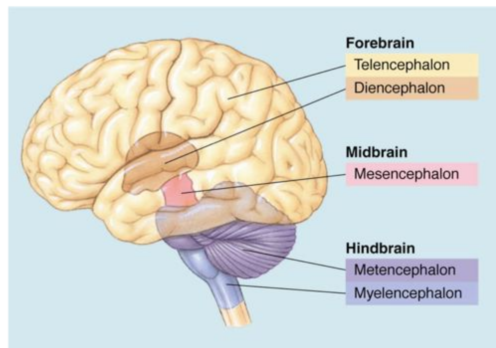
Notes: Organization

Version:
10/30/12 - original version

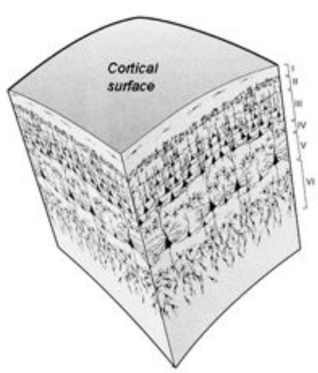
Anatomy of the Nervous System

Content covered in Hans's lecture:
CNS & PNS
Directions/Planes
Protection
Spinal Cord
-Encephalonic divisions (mnemonic: "*Start at the Top with T, then alphabetically*")



Cerebral cortex

Cortical layers



2-4 mm thick with white matter underneath
cortex has layers that differ in neuron organization
some layers consist mostly of:

________________ from ____________neurons__
signals arriving from other areas of the brain (_________)

____
densely packed neurons with many synapses (____________)

_________________ of neurons whose
axons project to other cortical areas (_________________)

________________ cells

- one of the main types of neurons in the cortex
- large multipolar (many extensions) neurons
- many dendrites extending up towards surface of cortex
- large axon that extends down and then to other areas of the cortex
  - these axons are what make up the white matter
- integrates signals and communicates to other areas of the brain

Occipital Lobe

Vision (*covered in unit 2*)

Parietal Lobe

Somatosensory cortex (*covered in unit 2*)

Association cortex (*covered in unit 2*)

- integrating vision (dorsal stream) / hearing / touch
- attention
- sense of space and our bodies relation to space

Temporal Lobe

(know functions but not names)

superior temporal gyrus (top) - ________________ and ________________

inferior temporal gyrus (bottom) - "what" or ventral stream of ________________

medial temporal lobe (inside) - hippocampus, declarative ________________

Frontal Lobe

primary motor cortex (________________ movement control)

secondary motor areas (________________ movement control)

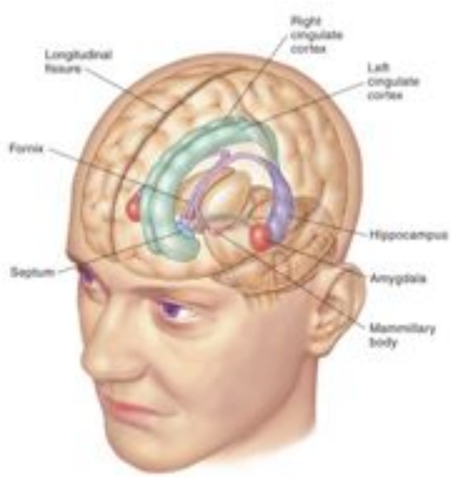
prefrontal cortex - advanced ________________ functions, ________________

- "pre" meaning before or in front of

Subcortical Structures

"subcortical" is everything under the cortex (the very outer surface)
includes areas introduced above: thalamus, hypothalamus, medulla, pons, cerebellum
includes the limbic system (more detail in Unit: Cognition) & basal ganglia (more detail in Motor System below)

Limbic system



circles the thalamus (limbic is Greek for ring)
regulates the four Fs of behavior:
- fighting, fleeing, feeding, and ____________

Areas

____
- declarative memory
  - knowledge that can be declared as oppose to procedural memory

____
- (Greek: almond)
- emotional learning, fear & aggressive behaviors

Basal ganglia

To be covered in Motor System of this unit

Motor System

Optional TED Talk - Daniel Wolpert: The real reason for brains (first 2:30 is most relevant, but good stuff after)
http://www.ted.com/talks/daniel_wolpert_the_real_reason_for_brains.html

Overview
- Responsible for controlling our ______________/skeletal muscle
- Capable of extensive ______________ and ______________

Requires extensive somatosensory _______________

Pathways

Upper Motor Neurons

Cell bodies in primary motor cortex
Travel down the spinal cord

Lower Motor Neurons

Synapse onto muscles - neuromuscular junctions
Their action potentials cause muscles to contract

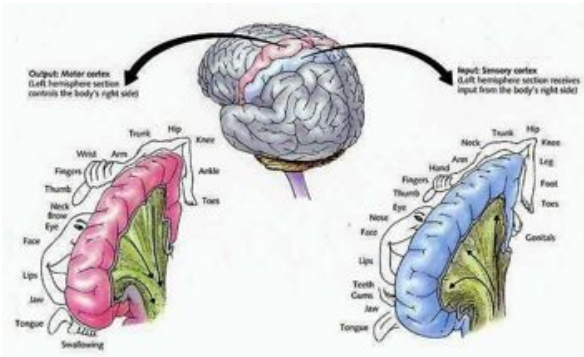
Dorsolateral Pathway

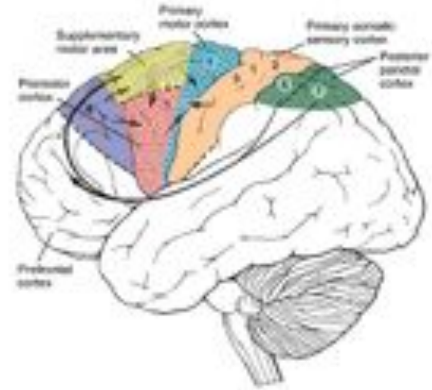
Necessary for ___________________________
Controls the distal muscles (e.g. hands, wrists, feet)
Axons go to only one specific segment of the spine
Lesions cause problems with fine movement (like moving some fingers but not others)

Ventromedial Pathway

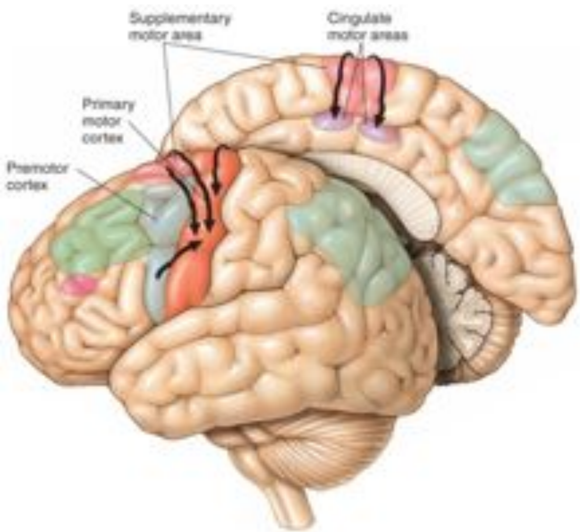
Necessary for _______________ and "anti-gravity"
Controls the proximal muscles (e.g. the trunk, neck, chest)
Axons go to many segments of the spine
Lesions cause problems with posture, sitting up, orienting

Brain Areas





Primary Motor Cortex



Role: Main source of output signals to control muscles
Input: secondary/supplementary motor areas & somatosensory cortex
Output: spinal cord (motor pathways)

Similar to somatosensory cortex
- Organized somatotopically
- Body regions with more refined control (hands, mouth) have larger representations

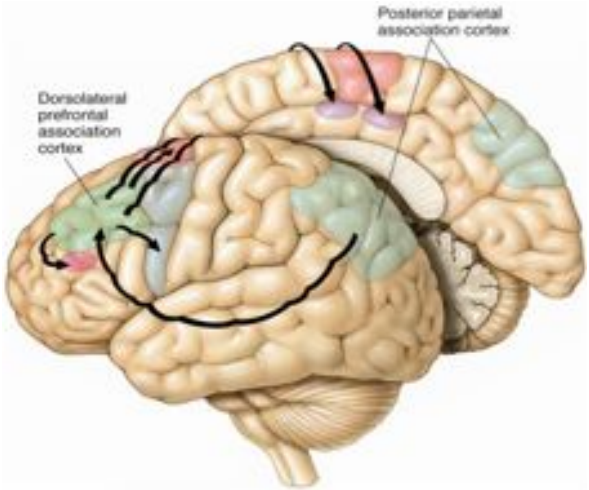
Electrical stimulation causes:
- Old view: simple, single muscle contractions
- Recent view: stereotypical, sometime multi-muscle movements
  movement towards a given endpoint regardless of starting position

Secondary Motor Cortex

Role: Planning and coordinating complex movements
Input: dorsolateral prefrontal cortex
Output: primary motor cortex

Includes: supplementary motor area and premotor area

Dorsolateral Prefrontal Cortex (DLPFC)



Role: _______________ which movement to make
Input: Posterior parietal
Output: Secondary motor areas

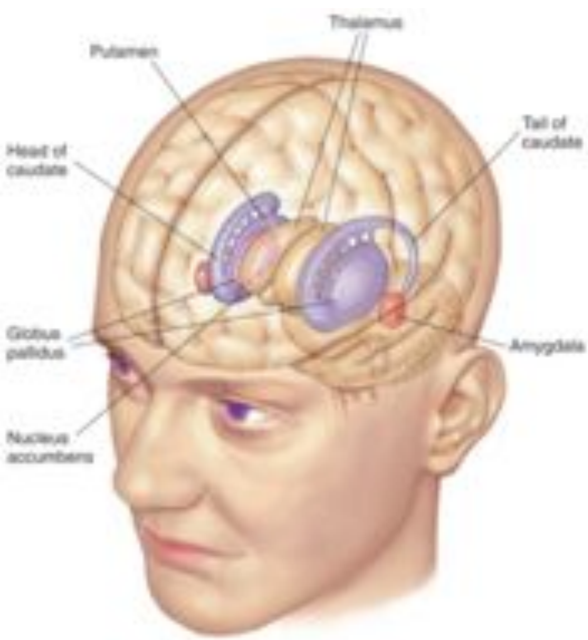
DLPFC is involved in far more than motor control
Responsible for higher cognitive functions:
working memory, rules, prediction

Posterior Parietal Cortex

(*previously introduced in Unit: Sensation*)
Role: Representing sense of body and space
Input: sensory systems
Output: dorsolateral prefrontal cortex (DLPFC)

Damage here can cause problems with voluntary movement (though not habitual/automatic movement)

Basal Ganglia



Role: Suppress ___________________________ action
Input: cortex
Output: cortex via thalamus

Serves as the gateway for selecting movement
It is as though the cortex is "proposing" many different actions and the basal ganglia selects only one

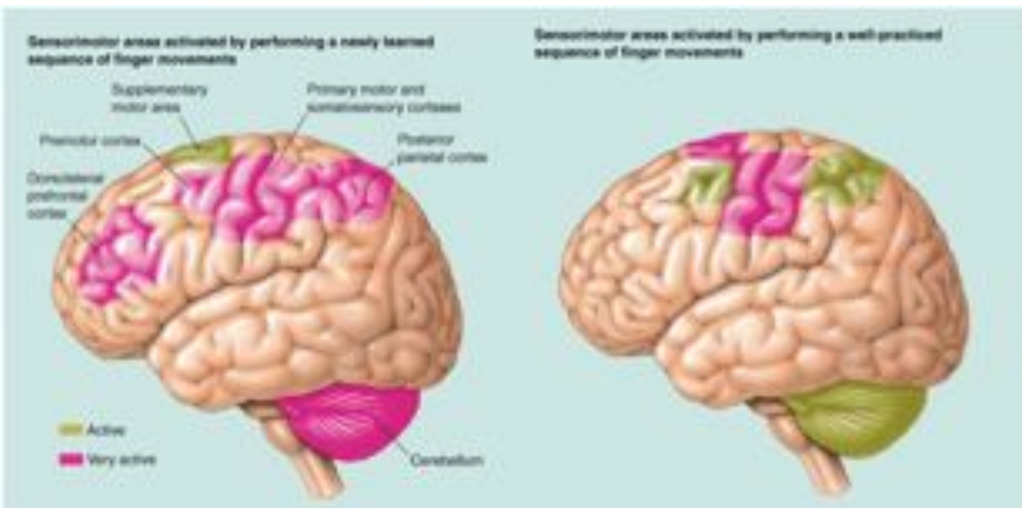
May also select _____________ and _______________ decisions

Cerebellum

Role: Motor learning and fine coordination
Input: Primary/secondary motor, sensory systems
Output: Primary/secondary motor

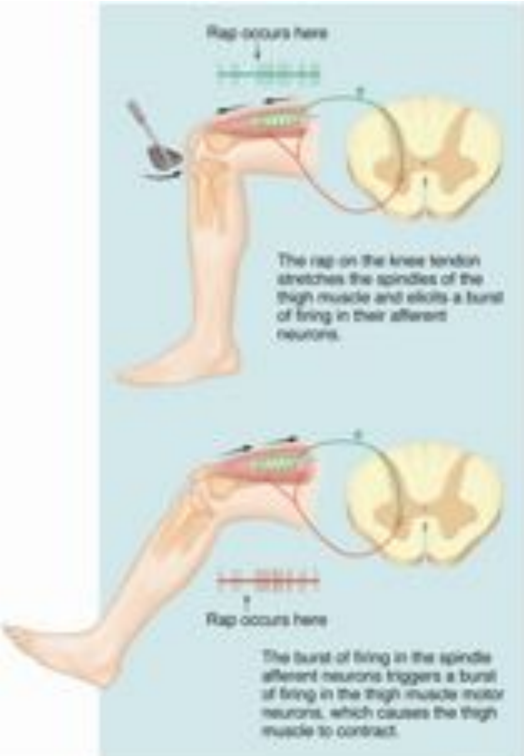
Receives a copy of the motor command, compares to desired output, makes small adjustments
Also the site of some motor learning (what people call "muscle memory")

Learning



Practice of motor programs changes which areas are involved
Strongly reduced involvement with practice: parietal, DLPFC
Always involved: primary motor cortex, cerebellum, basal ganglia
Practice is relieving higher brain areas of the need to be involved, allowing _______________

Reflexes



There are sensory neurons that synapse directly on lower motor neurons

Capable of producing movement without the brain

Advantages: _______________ and _______________

Respond to temperature, joint displacement, pressure

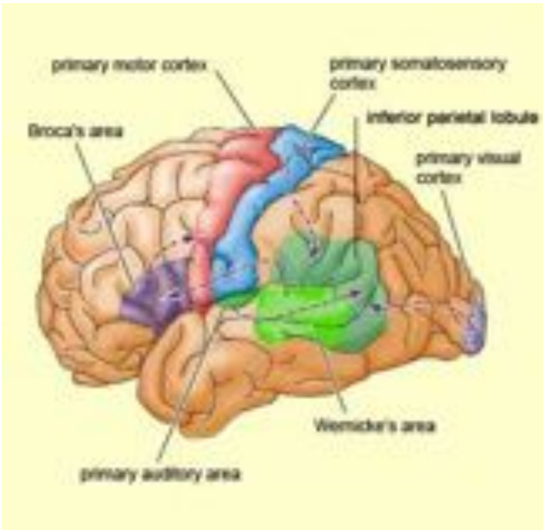
Lateralization

_______________ - function is more dependent on one hemisphere (left/right) than the other
contralateral - across/different sides
ipsilateral - same side

Lateralization

____

- problems with speech
- typically patients with aphasia have damage to _______________ hemisphere
- handedness
    - right handed people almost always have language in left hemisphere
    - left handed people usually have language in the left hemisphere



Source: mybrainnotes.com/memory-language-brain.html

Fun Facts (*will not be tested*)

Paul Broca & Carl Wernicke
- physicians in 1800's
- performed autopsies on people with aphasia
- noticed the reliability of damage to left hemisphere
- earliest evidence for lateralization in the brain

Wada Test

anesthetize one hemisphere of the brain at a time

can impair speech in conscious subjects

used to localize language before brain surgery

Optional videos:

Broca's aphasia - old, recent

Wernicke's aphasia - old

____

problems initiating movement *out of context*

movements *in context* can be routines that don't rely on cortex

associated with damage to left hemisphere

____

ignoring one side of the body / space / objects

typically associated with damage to right parietal lobe

other capabilities

findings of lateralization for: reading, faces, emotions, music, math, spatial reasoning, details/gist

often exaggerated in the popular media

differences can be minor and/or unreliable from person to person

after damage, other hemisphere can sometimes compensate or develop

expertise can exaggerate differences

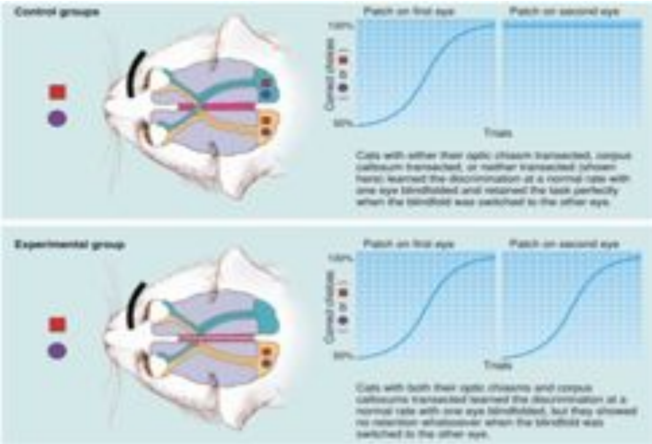
Split-brain patients

____________________________ can be surgically cut

done either experimentally (animals) or to treat epilepsy (humans)

effects in human patients are obvious/subtle

In cats (Myers & Sperry)



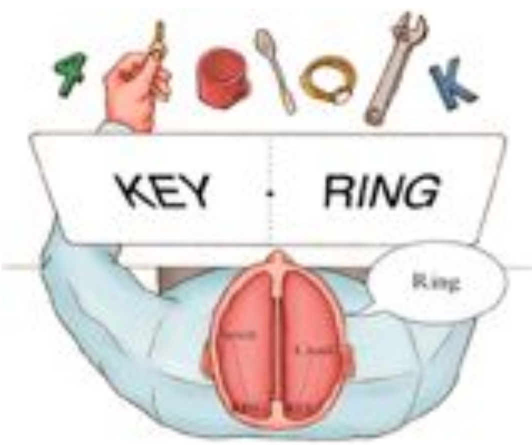
Full description of the experiment on P415-416 (8th ed.)

Four different treatments in the experiment:
A. no surgery
B. cut the optic chiasm
C. cut the corpus callosum
D. cut both optic chiasm and corpus callosum

One hemisphere learned as fast as both hemispheres still connected

Learning could be transferred across corpus callosum

In humans (Gazzaniga)



Source: brainmind.com/Brain3.html

Patients have corpus callosum cut as epilepsy treatment

Different objects/words could be presented to each hemisphere

Person would answer different depending on which hemisphere was responding (remember: language only on left)

2 hemispheres are functioning independently within a person

Videos: Gazzaniga w/ Alan Alda, Other

Development

How do we get from embryo to mature adult brain?

Neural Development

1. neural differentiation
   neurons and glia develop from ______________

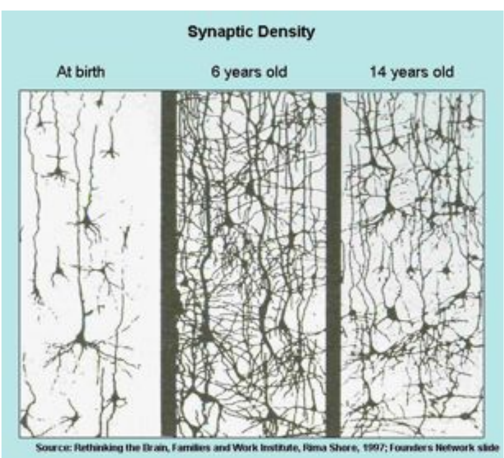
2. neural proliferation - creation of many new neurons
   happens at the borders of the ventricles

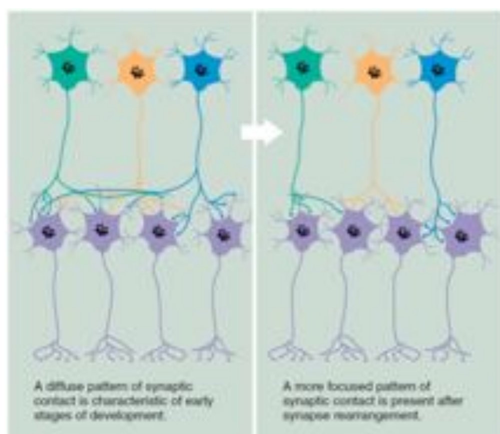
3. neural migration - neurons (without axons or dendrites) spread out to appropriate locations
   guided along paths by glial cells
   aggregate into cohesive structures

4. axon growth
   axon originates from cell body and is able to "find" targets throughout the brain
   growth cone
   chemoaffinity hypothesis - axons are guided by complex chemical signals

5. ___________________________
   growth of new synapses
   dependent on astrocytes

6. _______________
   we lose about 50% of the neurons that are originally created
   apoptosis - programmed self-elimination (cell death)
   neurons start with many more connections than needed,
      then lose connections with other neurons,
      but increase synaptic strength with the connections that remain
      example: initially many motor neurons connect at each neuromuscular junction,
         but in adulthood only one motor neuron remains connected (competition)





Timing of Development

24 days - neural tube

40 days - initial swellings of fore/mid/hind brain

maximum neurons at ___ years old

primary visual cortex
  synaptogensis in 4th month post-natal
  "maximum synaptic density (150% of adult levels) in 7th month post-natal"

brain increase 4x in volume from birth to adult hood
  NOT due to _______________
  due to:
    synaptogenesis
    myelination of axons
    increased branching of dendrites

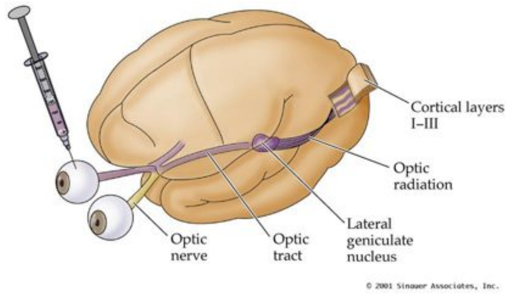
prefrontal cortex
  longest period of development (_______________)
  maximum # of neurons in 2nd year
  spurt of neuronal growth just before puberty, then a pruning in adolescence (Giedd 2004)
    losing 1% of gray matter per year
    teens have less myelin than adults in PFC (Giedd 2004)

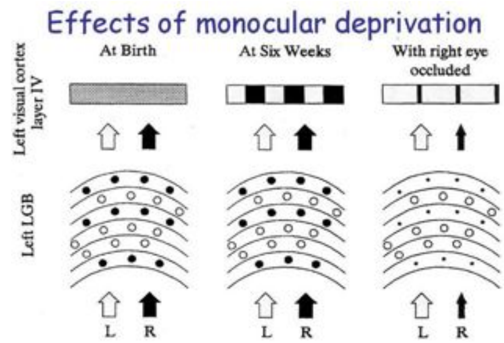
Critical Periods

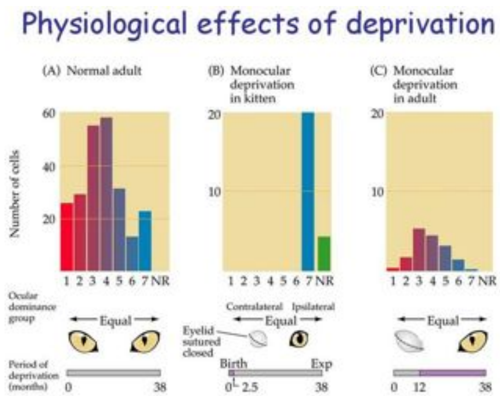
critical period - a time when an organism must have an experience to develop a capability
driven by the competitive nature of neurons
examples: visual development (below), imprinting in ducks & geese, necessity of early social experience in primates

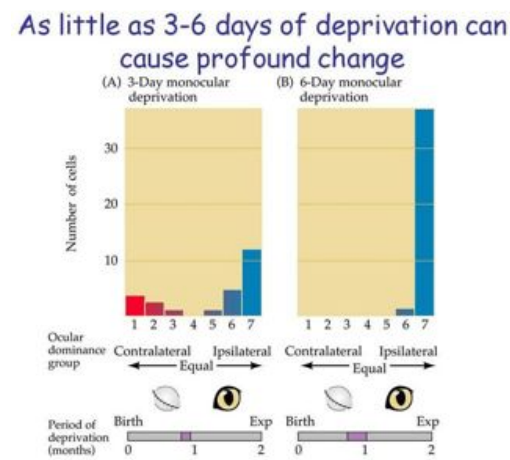
sensitive period - an experience is highly influential on development of a skill
  these tend to be more loosely defined and arguable than critical periods

The effect of depriving one eye on the development of the visual cortex









Source: Originally from "Neuroscience" by Purves, posted on bbs.stardestroyer.net/viewtopic.php?t=124049

Principles

Neural development milestones are spread out from 1 month after conception to 20 years old

Neural organization is characterized by upfront overgrowth followed by pruning

Neurons show competitive behaviors during development

Different brain areas have different growth and critical periods