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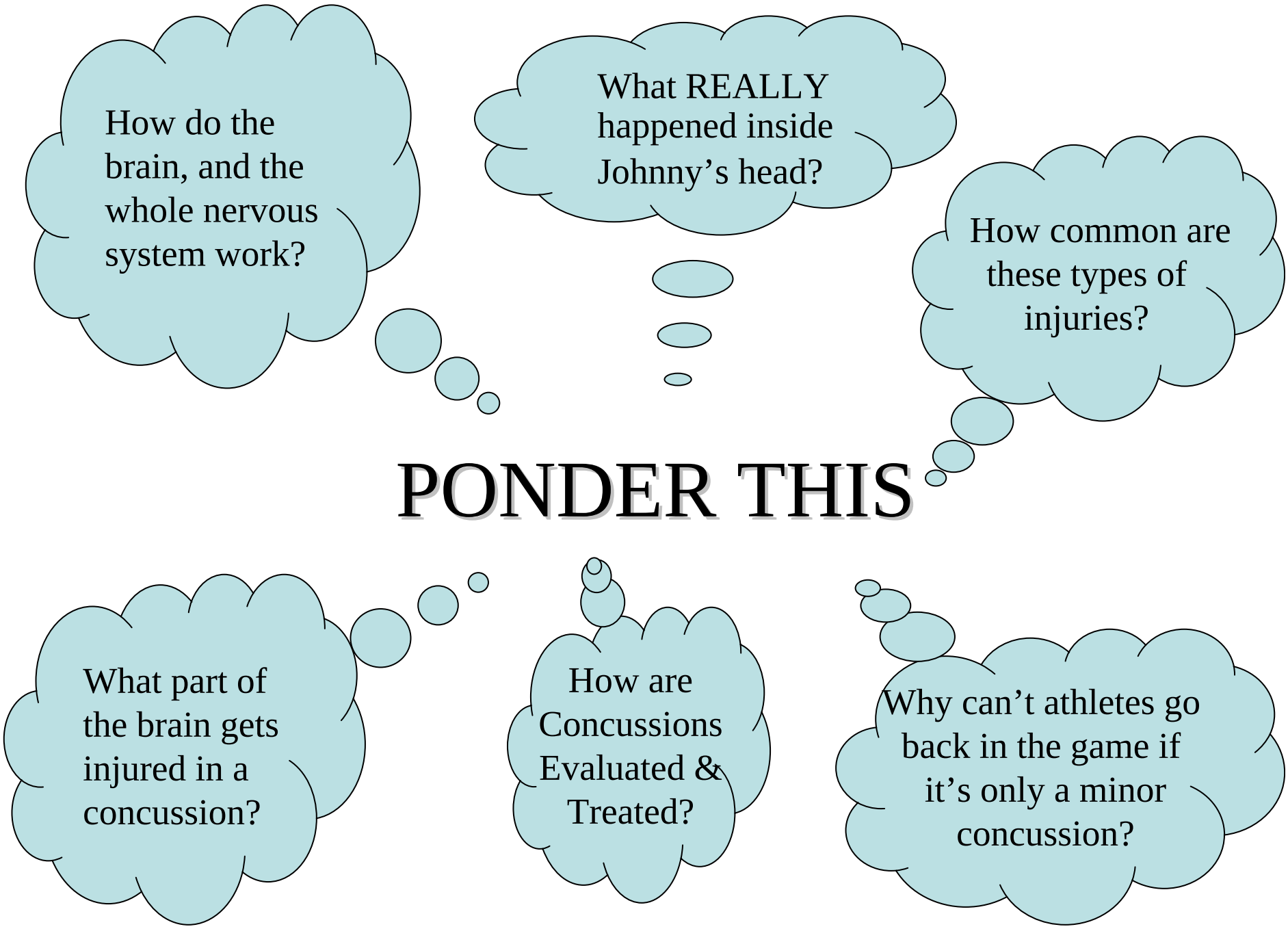
The Brain & Sports-Related Concussions

A little miscommunication mistake...

Chronicle / Lacy Atkins

could lead to a serious injury.

Fortunately, these guys were relatively lucky.


How do the brain, and the whole nervous system work?
What REALLY happened inside Johnny's head?
How common are these types of injuries?
PONDER THIS
What part of the brain gets injured in a concussion?
How are Concussions Evaluated & Treated?
Why can't athletes go back in the game if it's only a minor concussion?

I. Introduction to the Nervous System

Table of Contents

The CNS & PNS

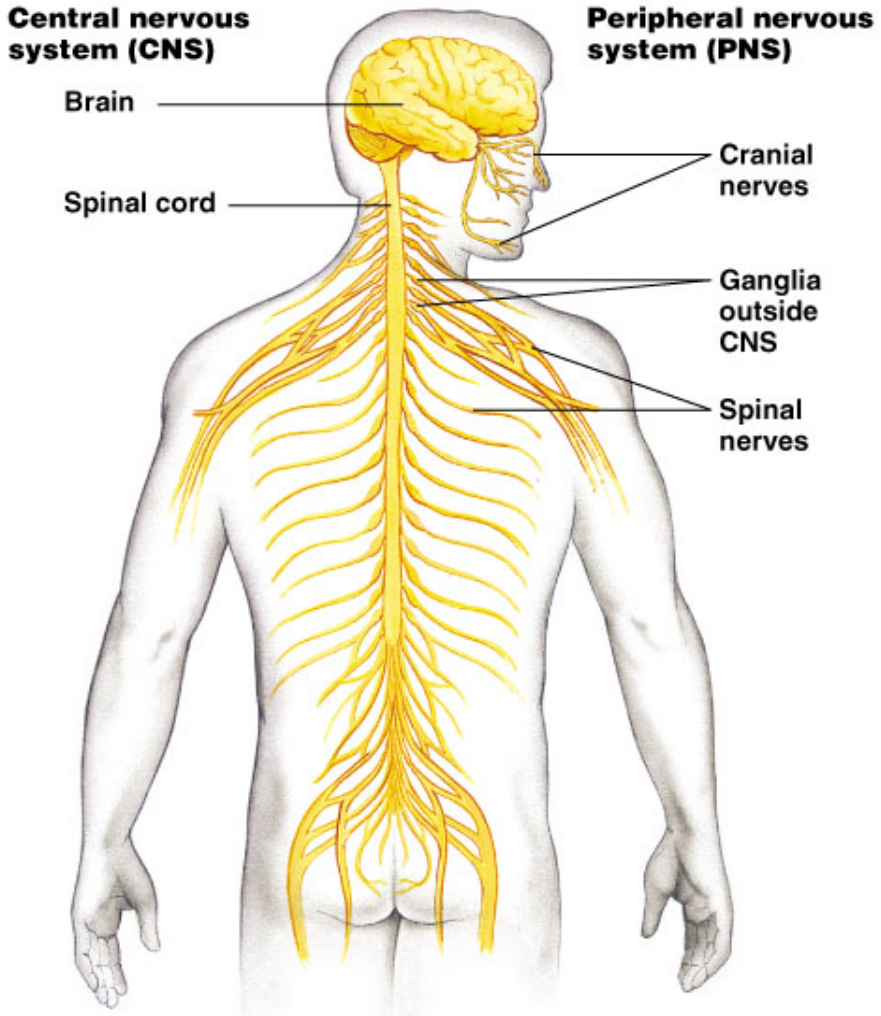


Image from Campbell Biology 7th Edition

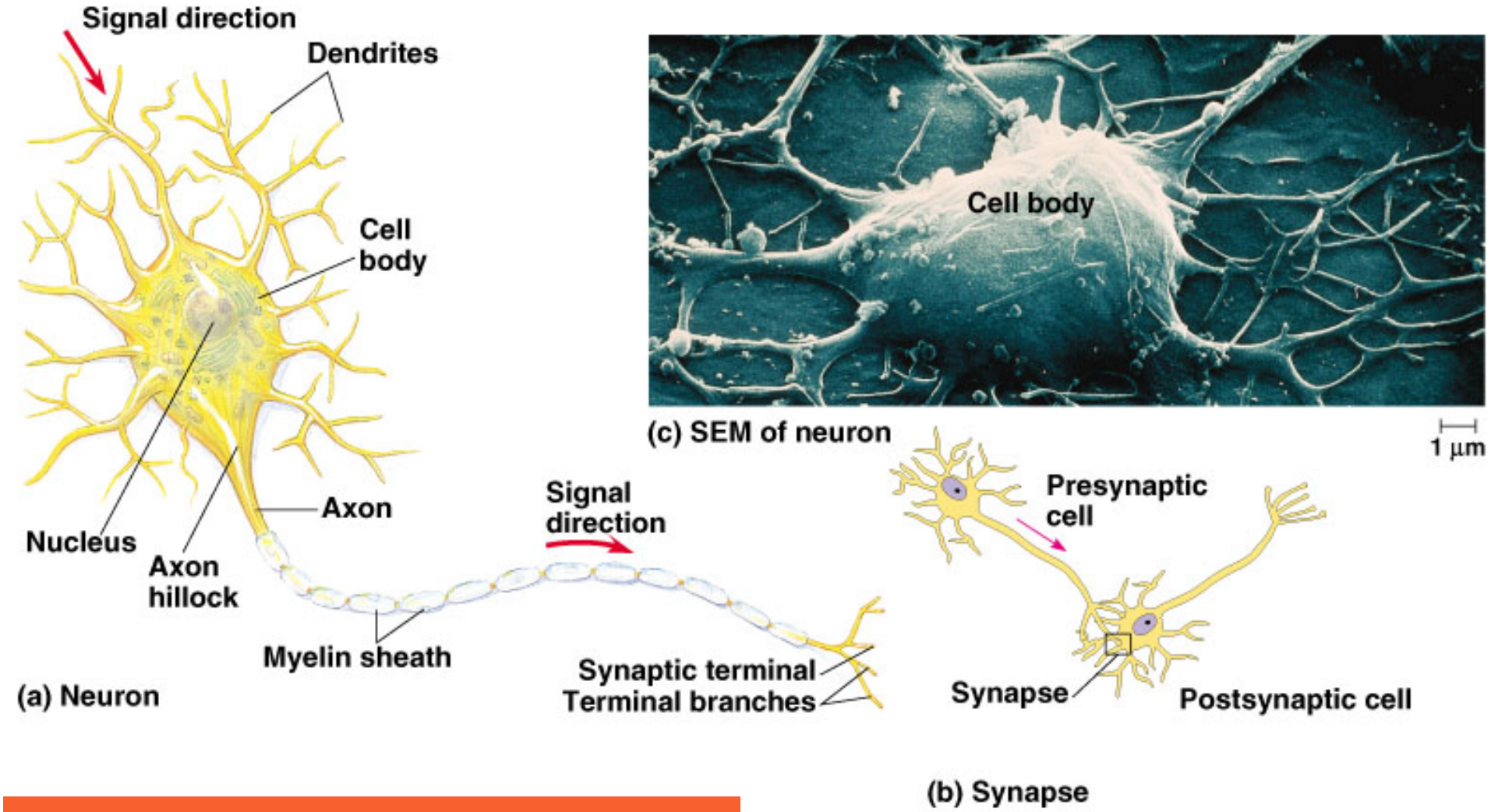
Neurons

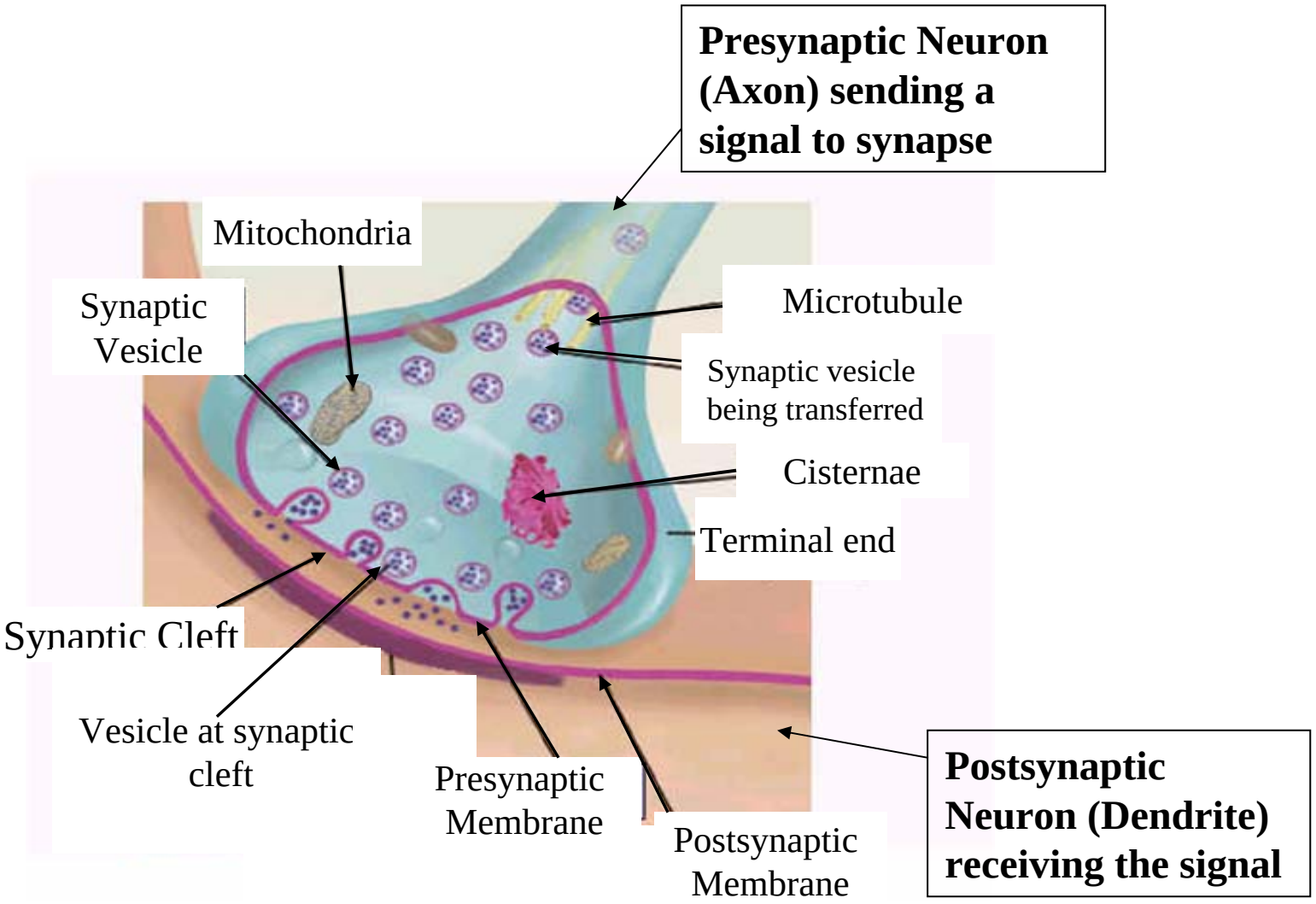
- Neuron= single nerve cell that has 3 main parts:
  - Dendrites: Receive signals from other neurons
  - Soma or Cell Body: contains the nucleus
  - Axon: Sends signals to another neuron

- FUNCTION:
  - send and receive information (electrical, mechanical, and chemical signals, etc)
  - Signals travel: CNS $\longleftrightarrow$ all parts and systems of the body

- EXAMPLES:
  - sensory signals from body to CNS & response signal back to body as motor signals. (hot stove, soccer ball, balancing, etc)

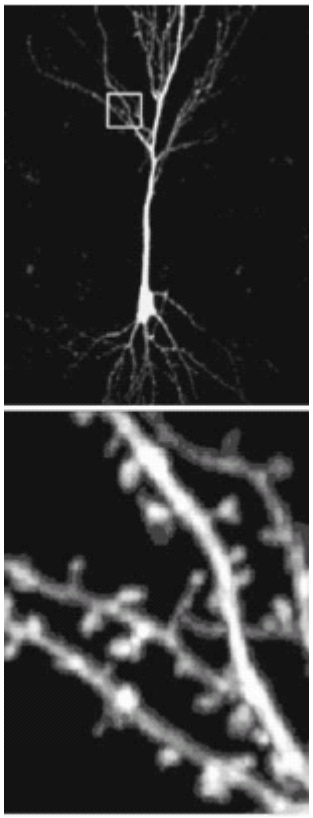
Neuron Structure and Synapse

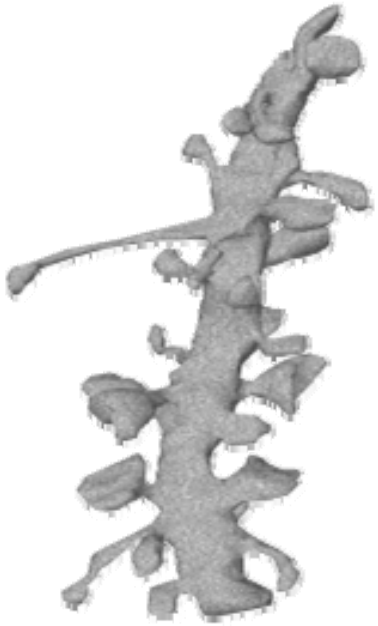


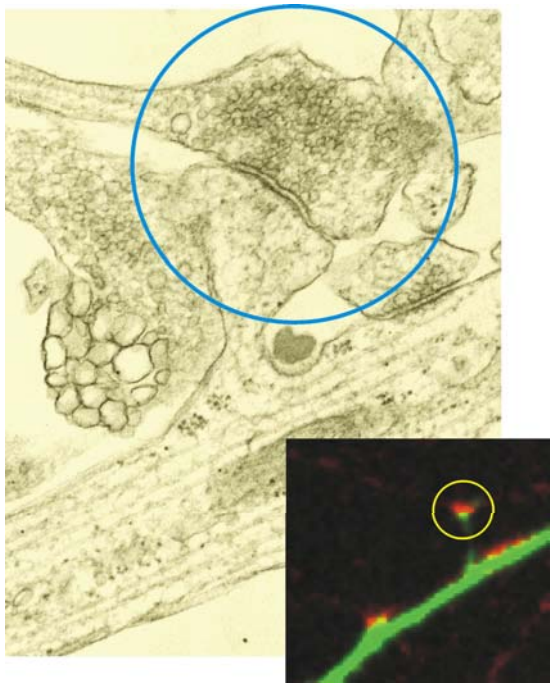


The Synapse: Site of Neuron Communication

Microscopic View of Real Synapses







Neuron Communication: Action Potential

Summary:

A wave of action potentials reach the end of the axon.This electrical signal is converted into a chemical signal. This chemical or neurotransmitter crosses the space (synapse) between adjacent neurons and this initiates an action potential on another neuron.

Neural Communication: Step by Step

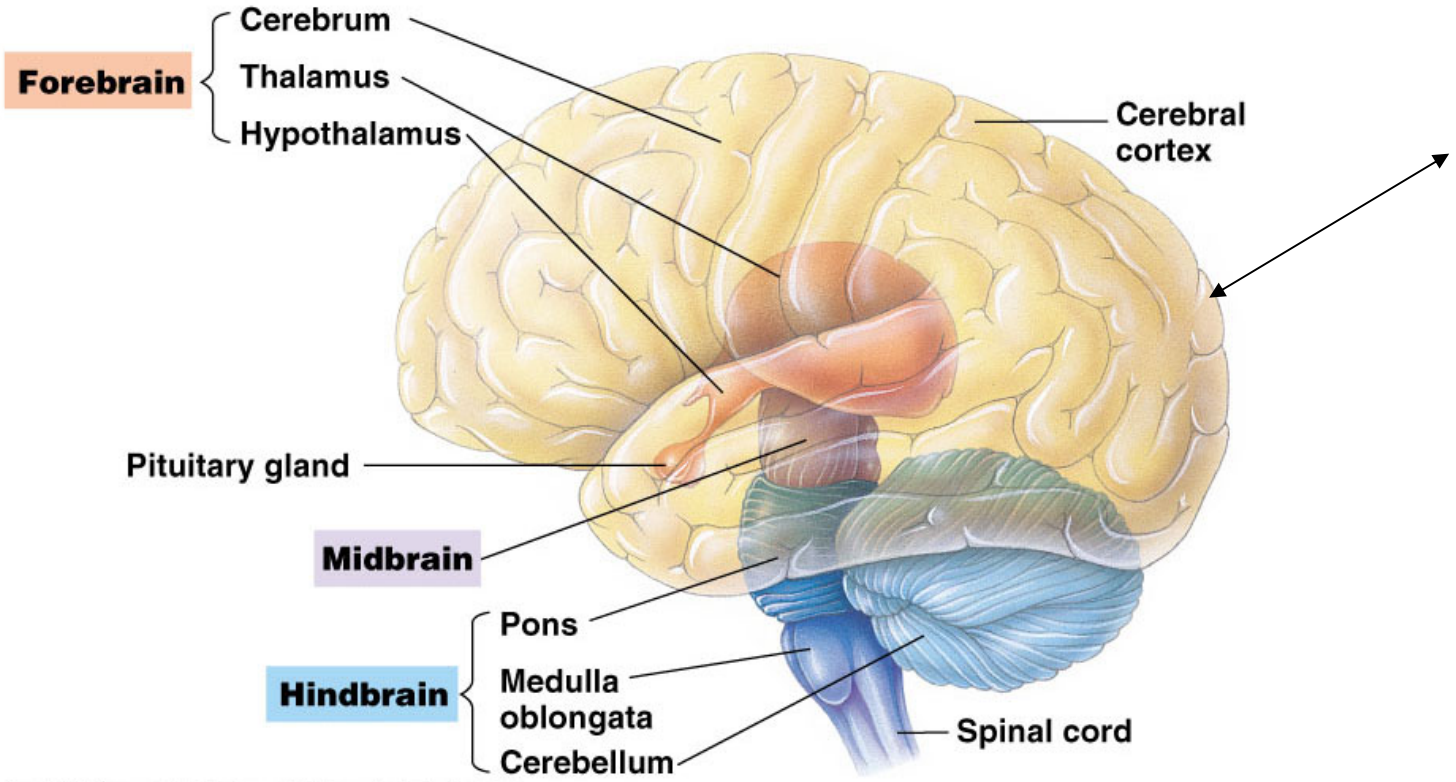
AP activates Ca++ channel and Ca++ diffuses into the neuron. This Ca++ causes vesicles to fuse with the cell membrane.

Through exocytosis, neurotransmitters (chemicals) are released into the synapse. These neurotransmitters diffuse across the synapse and bind to receptors on post-synaptic neuron.

This causes special Na+ channels to open and an action potential Is initiated in the next neuron.

Once the message has been passed on to the post-synaptic neuron, the neurotransmitter is reabsorbed into the axon, diffuses away or it is destroyed by an enzyme.

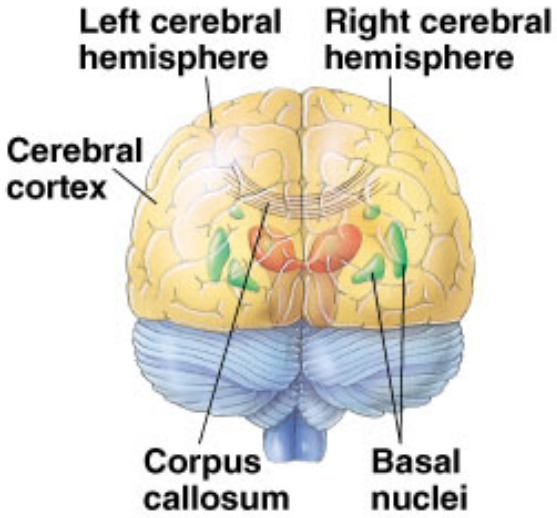
The Human Brain



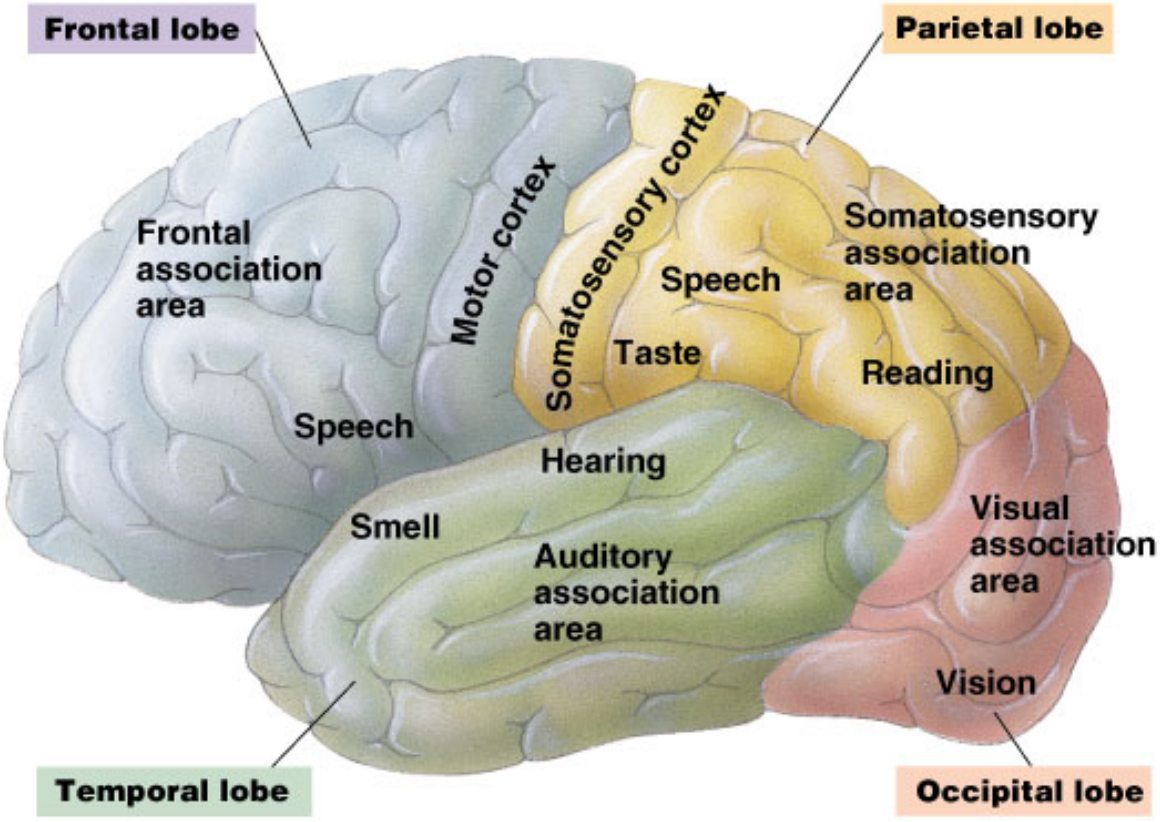
The Cerebrum has different areas for different functions

Four lobes: Frontal, Parietal, Temporal, Occipital

Left & right hemispheres: connected by the Corpus callosum



(a) Back of brain



(b) Left side of brain

The Brain Needs lots of TLC: Protection and Nutrition

Brain Protection

1. Outer layer: scalp (skin)
2. Bony protection: Cranium (skull)

Ethmoid bone

Sphenoid bone

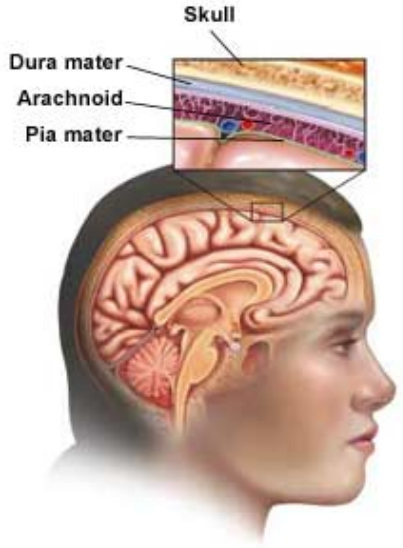
QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.

Cranial sutures:

Areas where the bones have fused (early development) to form the cranium.

3. Specialized coverings called Meninges:

- Dura Mater- outermost
- Arachnoid Layer- middle
- Pia Mater- innermost



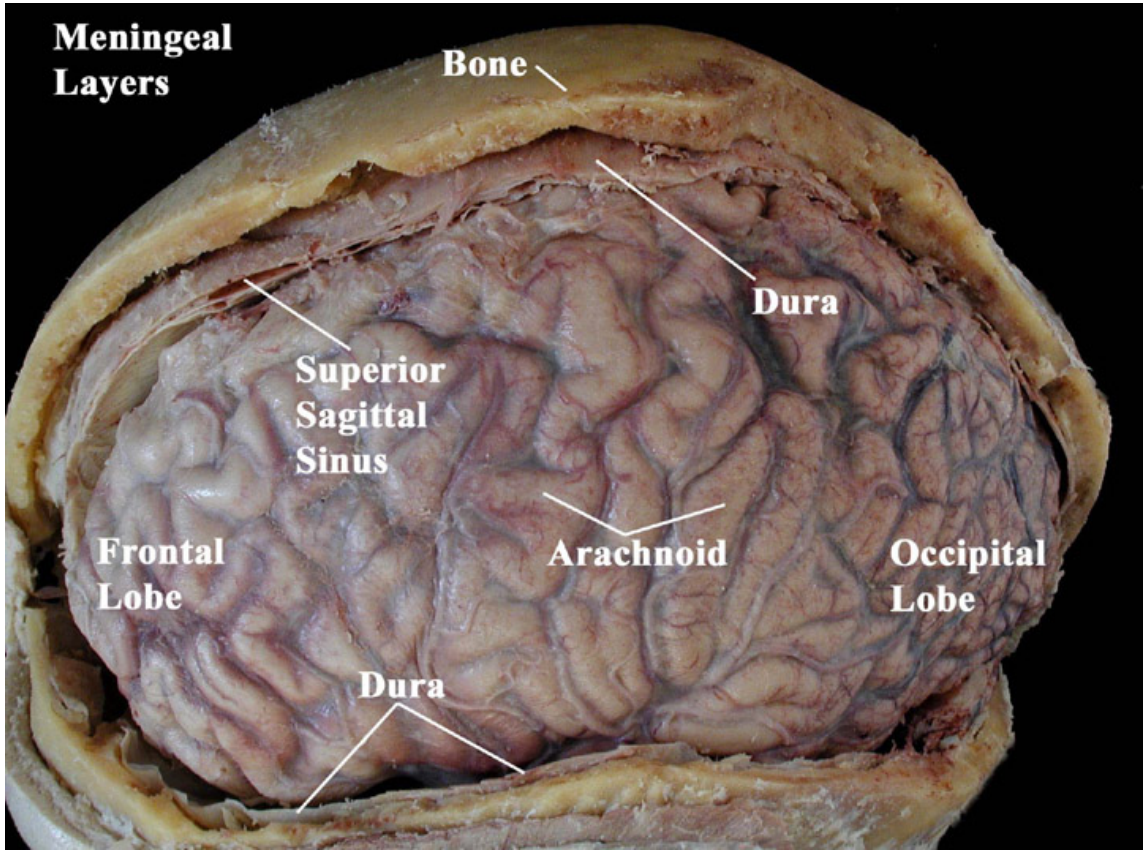
**Here's a good way to remember the order of the meninges (innermost To outermost): "The meninges PAD the brain." (Pia, Arachnoid, Dura)*

www.washington.edu/chudler/meninges.html

Foramen magnum:

Opening at base of cranium (occipital bone) where the medulla oblongata extends, and nerves & blood pass into and out of the brain.

Check out the Meningeal Layers in a REAL brain!



4. Cerebrospinal Fluid (CSF) in Ventricles (fluid-filled cavities)

Functions of CSF in this system of ventricles:

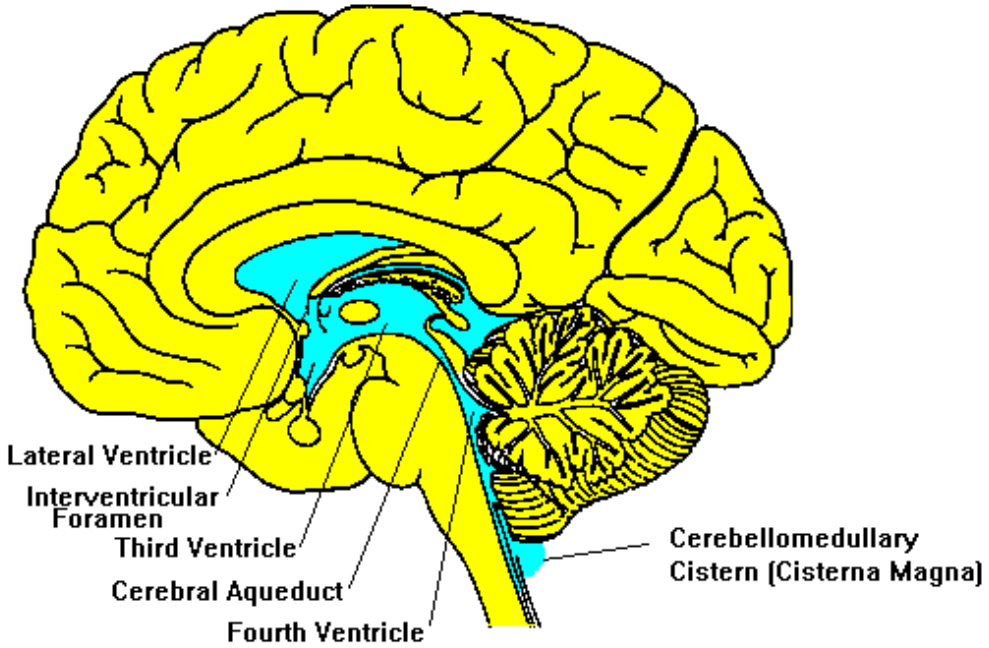
A) Cushions the brain from a blow to the head *Mr. Egghead

B) Provides buoyancy (decreasing pressure at the base of the brain)

C) Excretes waste products through a one-way valve

D) Transports hormones to other areas of brain

Mid-Sagital view of ventricles with CSF



3-D view of ventricles with CSF

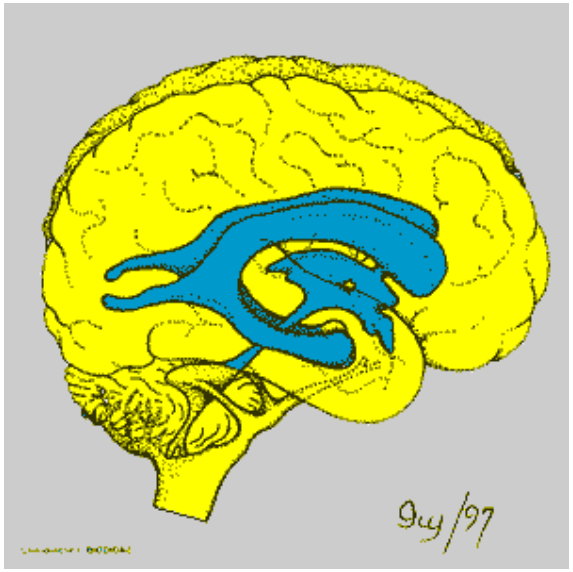
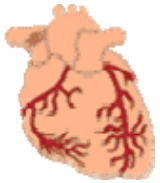
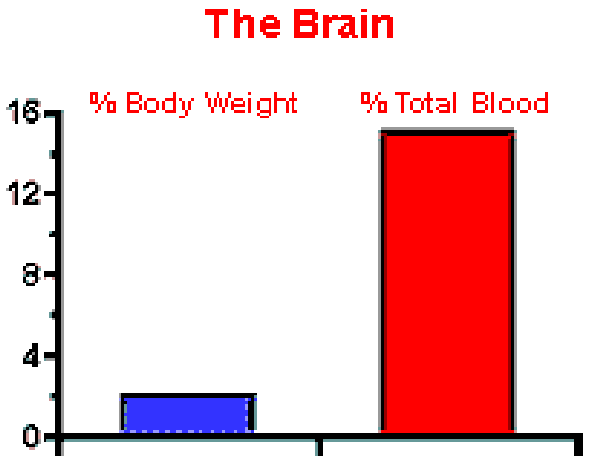


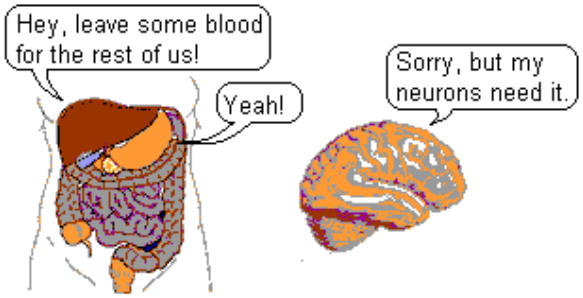
Image adapted from Biodidac



Brain Nutrition

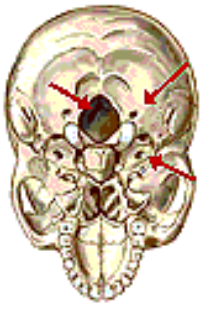


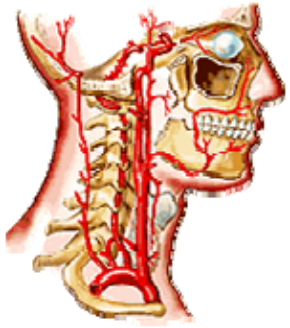
- Deep and superficial blood vessels-> BRAIN
- Brain is 2% of the total body weight in humans
- Brain receives 15-20% of body's blood supply.



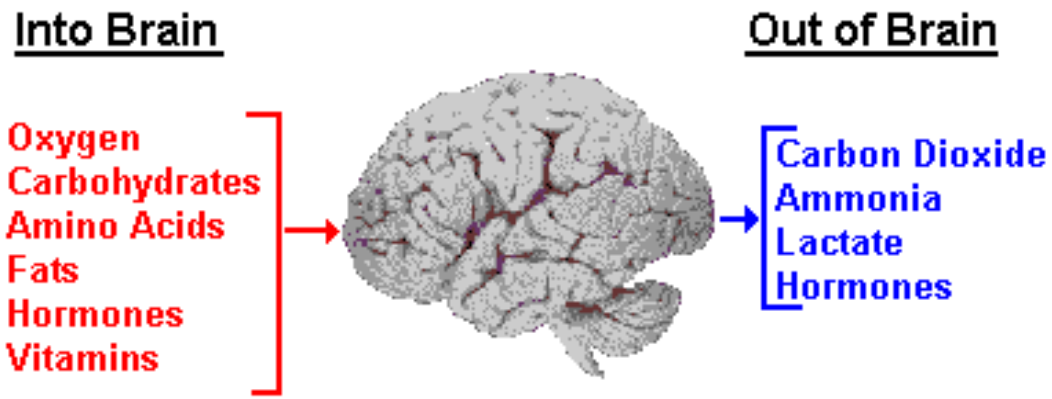
- Brain's blood supply stops = brain cell death
- Brain has top "blood priority" over all organs

- Blood vessels reach the brain through the cranial foramina (labeled with red arrows).

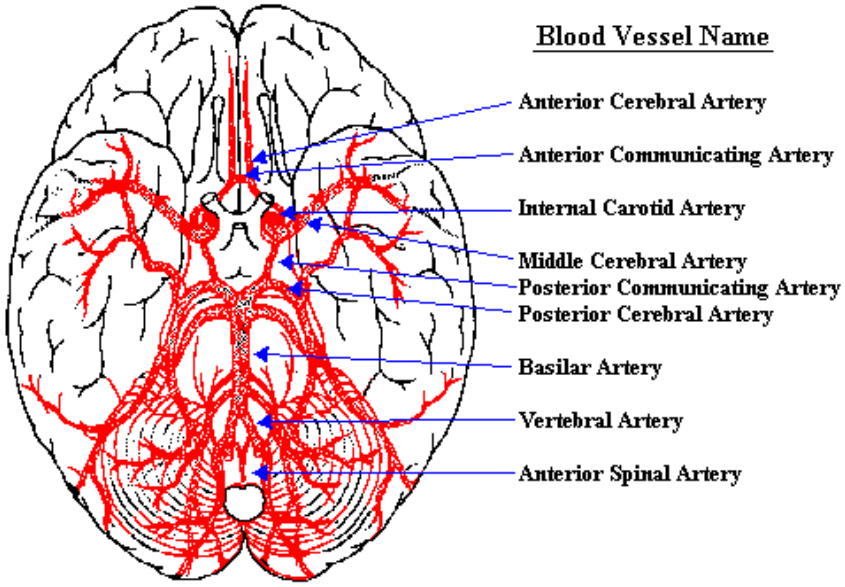




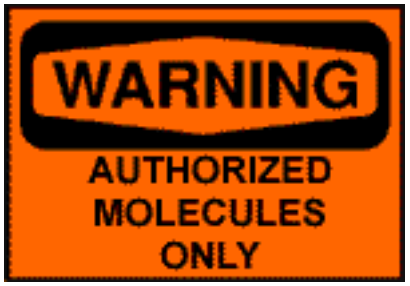
Brain Metabolism

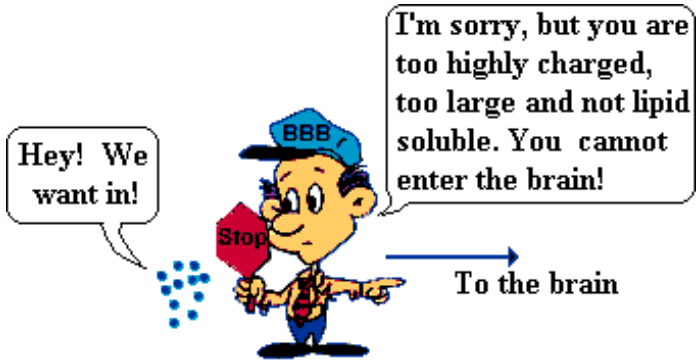


An inferior view of the brain's blood vessels



What is a brain attack ? For information, click HERE.





Blood Brain Barrier (BBB)

- The brain is *selective* in what substances it allows in and out via blood
- Functions of the BBB:
  - Protects the brain from "foreign substances" in the blood
  - Protects the brain from hormones and neurotransmitters in the body
  - Maintains a constant environment for the brain.
- The BBB can break down under certain conditions:
  - hypertension, radiation, infection, and brain trauma, etc.

Nervous System Review Games

- Group Trivia (basic review questions)
- Pictionary (small groups)
- Jeopardy (PowerPoint for whole class) download Neuroscience for Kids: Brain Games
- Online Quiz at the Mayo Clinic Brain & Nervous System Center

II. Sports-Related Brain Injuries

• **Of the estimated 1,500,000 people who sustain TBI's each year in the United States:**

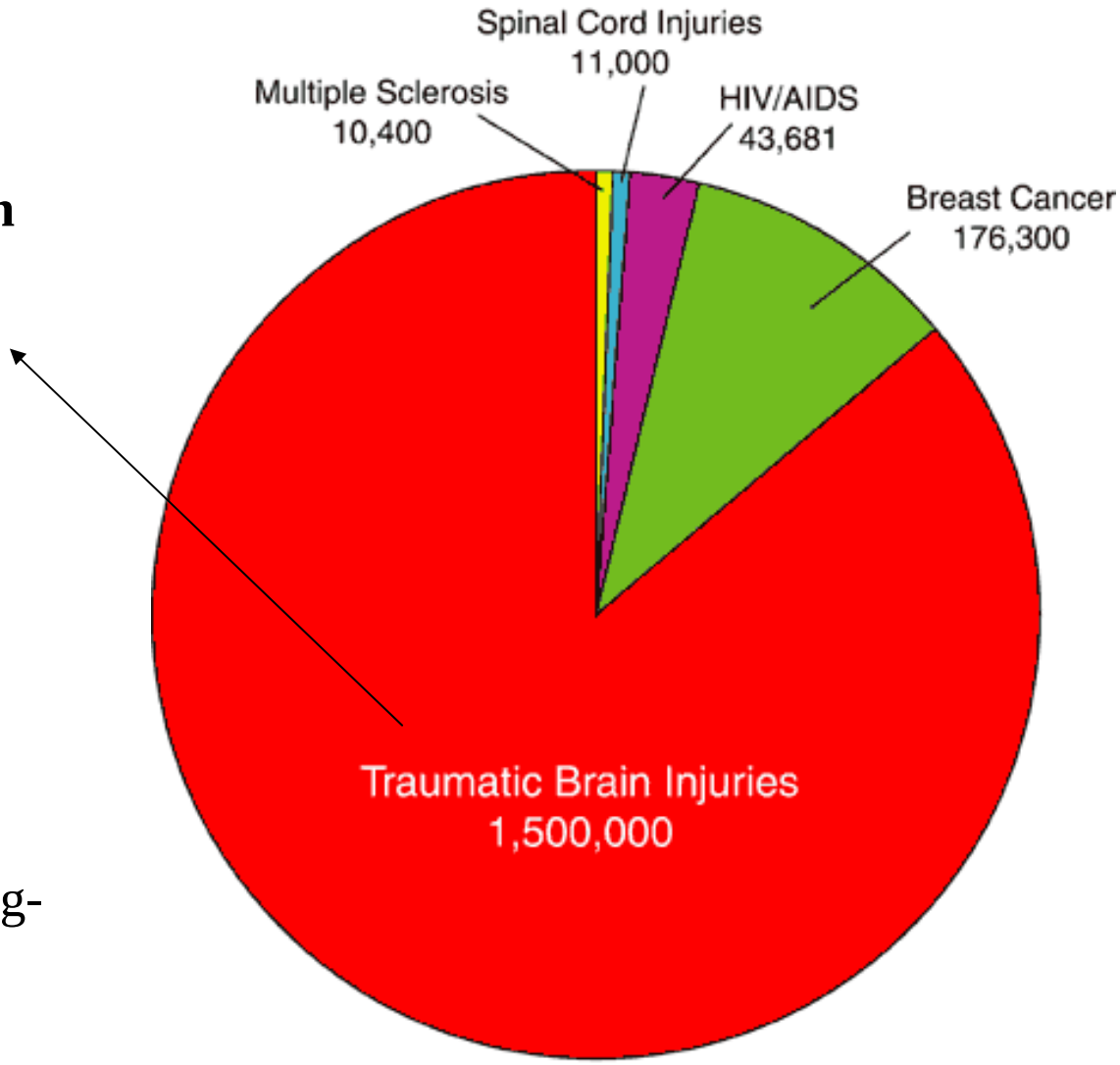
•1.1 million treated & released from an Emergency Dept.

•235,000 hospitalized

•50,000 die

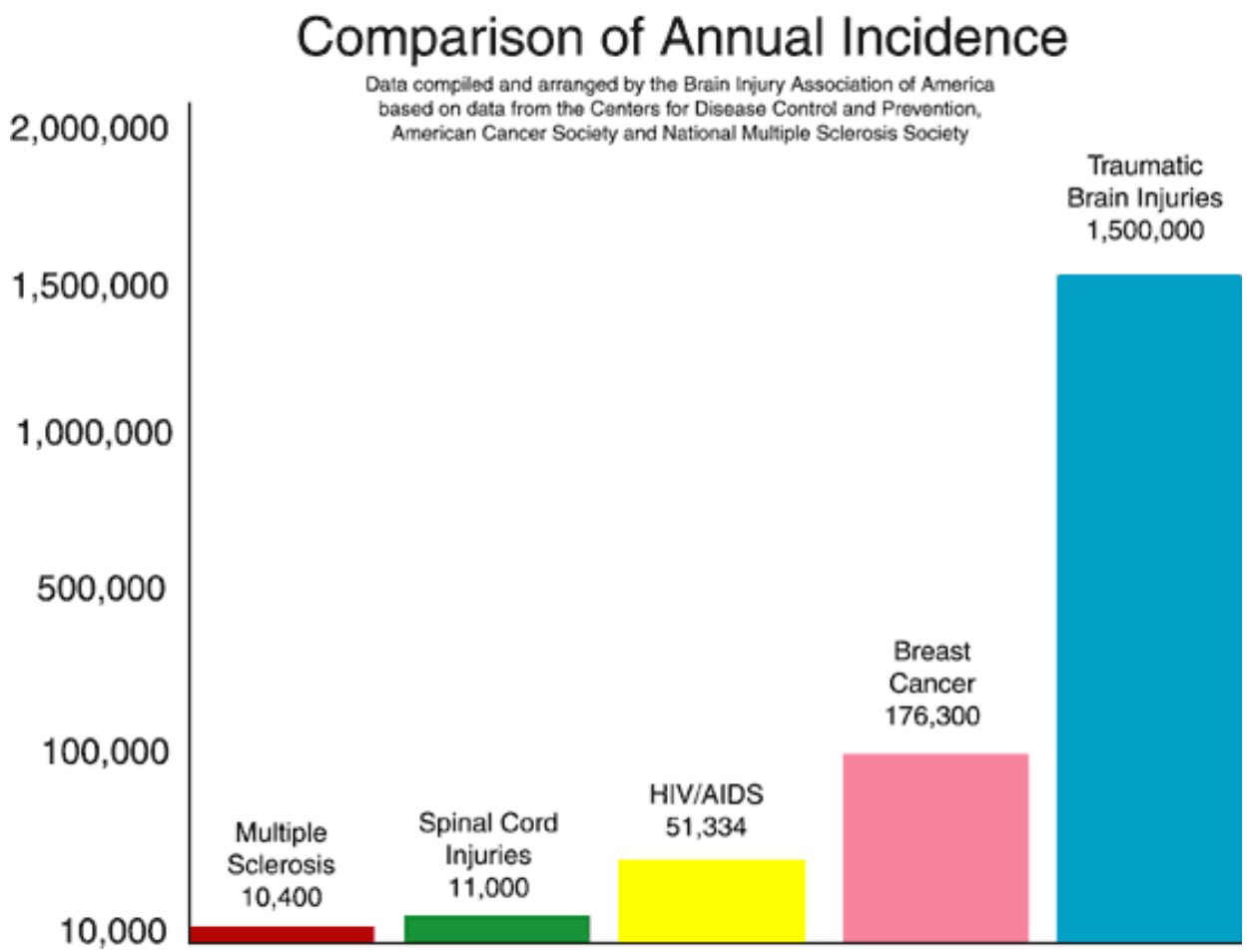
•80,000 experience onset of long-term effects from a TBI

•5.3 million Americans (2% of population) living with a disability as a result of a TBI



Comparison of Annual Incidence

Data compiled and arranged by the Brain Injury Association of America based on data from the Centers for Disease Control and Prevention, American Cancer Society and National Multiple Sclerosis Society



Estimated annual costs from TBI's:

$56.3 billion

Leading causes of TBI:

- Motor-vehicle crashes
- Falls & sporting accidents
- Violence & firearms
- Blasts #1 cause in military

Risk factors for TBI:

- Males 1.5-2 times as likely as females
- Ages 0-4 years, **15-19**, & elderly (>75)
- African Americans have highest TBI death rate
- Military duties increase risk of TBI

Concussions:
Common Sports Related TBI's

Table of Contents

Definition of Concussion

“-A violent blow, jarring, shaking or other non penetrating injury to the brain. Frequently, but not always, accompanied by a loss of consciousness. Also called Minor Head Injury and Traumatic Brain Injury. Slang terms include: having one's "bell rung," and "ding. -Head Injury Hotline

Three Categories of Concussions
(based on severity of symptoms)

*LOC = loss of consciousness

Grade 1

transient confusion & no LOC*

mental status abnormalities for **<15 min**.

Grade 2

transient confusion & no LOC

mental status abnormalities for **>15 min**.

Grade 3

Any LOC-

brief or prolonged (seconds, minutes or longer)

Prevalence of Concussions in Sports

- Majority of an estimated **300,000** sports related TBIs that are mild-moderate severity

- Collegiate Stats (2002-2003 season, per 1,000 athletes)
  - Football: **3.52** per game/practice
  - Ice Hockey: **2** per game/practice
  - Men's Soccer: **1.13** per game/practice
  - Women's Soccer: **1.8** per game/practice (from NCAA found in Discover Magazine)

- A study of collegiate football players showed that players who'd had >3 concussions had **3x the rate of depression**.

- For a story of Harry Carson, an ex-NY Giants linebacker click HERE

What happens to your brain?

STAGE 1:

An impact slams the brain against the skull

- The axons that carry impulses from neuron to neuron stretch unnaturally, garbling their signals
- The neurons fire simultaneously, causing a miniseizure. As they fire, K^+ rushes out of them and Ca^+ rushes in, clogging the neurons' mitochondria.

STAGE 2:

To fuel the absorption of new potassium, the neuron consumes glucose. (sugar)

- Metabolizing glucose creates lactate, an acid that damages cell walls.

STAGE 3:

The calcium-clogged mitochondria don’t get needed O_2. This causes a neuronal energy crisis. Blood flow drops and cells begin to die.

“Concussions can trigger a chemical chain reaction in brain neurons that leaves an athlete disoriented, unconscious, or dead. They can also impair learning over a period of years.”

What do other researchers say about concussions?

" ...during the minutes to few days after concussion injury, brain cells that are not irreversibly destroyed remain alive but exist in a vulnerable state. This concept of injury-induced vulnerability has been put forth to describe the fact that patients suffering from head injury are extremely vulnerable to the consequences of even minor changes in cerebral blood flow and/or increases in intracranial pressure and apnea....

Experimental studies have identified metabolic dysfunction as the key post-concussion physiologic event that produces and maintains this state of vulnerability...The result is an inability of the neurovascular system to respond to increasing demands for energy to reestablish its normal chemical and ionic environments. This is dangerous because these altered environments can kill brain cells."

Measuring Brain Metabolism from Injuries

Metabolism = Level of Activity and Function

High

Medium

Low

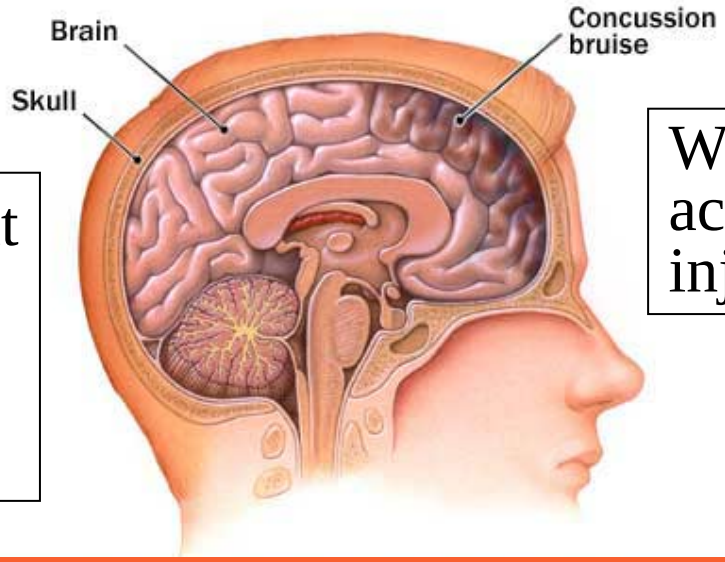
“THE PATIENTS, WHO WERE CONSCIOUS AND THOUGHT TO HAVE ONLY MILD INJURIES, ACTUALLY HAD VERY LOW BRAIN METABOLISM. IN FACT, THE METABOLISM WAS AS POOR AS SOME COMA PATIENTS WITH SEVERE HEAD INJURIES. THIS SUGGESTS THAT EVEN IF A BLOW TO THE HEAD REVEALS NO MAJOR OUTSIDE SIGNS OF TROUBLE, THERE STILL MAY BE SOME PROBLEMS INSIDE THE BRAIN.”

Do you remember?

What are the other 2 lobes called?

Which of the meninges is directly on top of the brain?

Which lobe is injured here?



What symptoms might you expect if the occipital lobe was injured?

What types of activities might cause injury in this area?

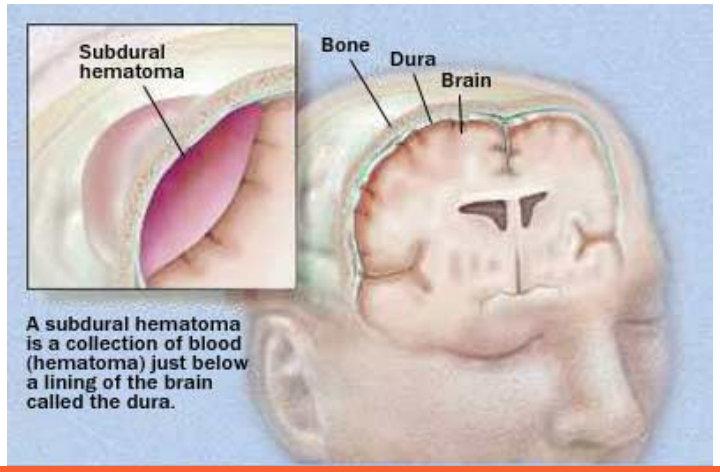
Concussion Signs and Symptoms

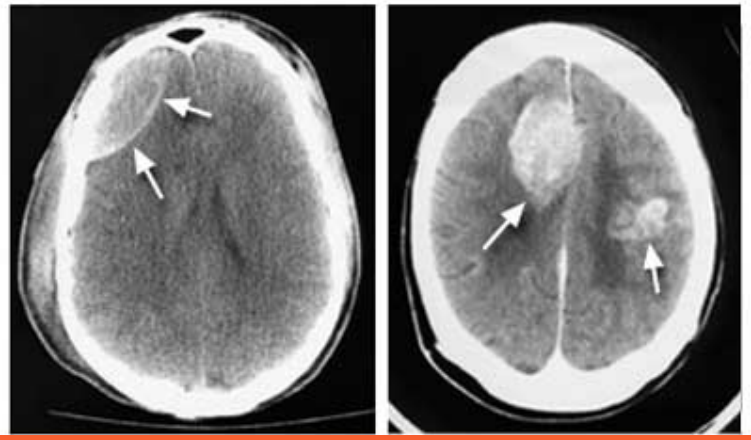
Signs and Symptoms vary, and may include one or many of the following:

- Unequal pupil size
- Vacant Stare
- Tinnitus (ringing in the ears)
- Nausea & Vomiting
- Delayed verbal responses
- Delayed motor responses
- Confusion & inability to focus
- Memory deficits
- Emotions out of proportion
- Slurred or incoherent speech
- Gross observable incoordination
- Disorientation (time, date, location)
- Any period of LOC
- Headaches and Irritability
- Sleep Disturbances
- Depression may develop

Some Related Conditions

- **Contusion and Edema**
- **Skull Fracture**
- **Intracranial Hematoma**
  - Subdural or epidural
  - A blood vessel ruptures
  - collection of blood compresses brain tissue.





Left: Arrows indicate an epidural hematoma, a collection of blood between the skull and the outer covering of the brain, which is compressing the right frontal lobe.

Right: Arrows highlights tumors in both sides of the brain.

Assessment and Imaging

1. Neurological Exam: (Athletic Trainers, EMT's, Doctors)

   A series of questions and simple commands to observe level of consciousness, measure sensory and motor skills and assess the function of the cranial nerves

   *(*Hospitals use*: Glascow Coma Scale* & *Rancho Levels of Cognitive Functioning)*

   LINKS: View Coma Scales , Mental Status Testing

2. Imaging: (Specialists in a Hospital)

   Variety of different imaging methods using specialized machines to study anatomical structures and abnormalities of or associated with the brain

Types of Imaging

- **X-Ray**: Radiation view bone structure
- **CT Scan** (CAT scan): Different type of X-ray shows brain and soft tissue (15-30 min)
- **MRI** (magnetic resonance imaging): Large magnet and radio waves used, 60 min.
- **Angiogram**: views damaged or spasming blood vessels by injecting dye into an artery through a catheter, 1-3 hours
- **ICP Monitor**: measures intracranial pressure by inserting small tube into/on top of brain through small hole in skull
- **EEG** (electroencephalograph): measures electrical activity in brain by placing electrodes on head, painless and time varies.

Treatment

- **Initial Treatment: Evaluation**
  - Emergency Response
    - level of consciousness, ABC's (airway, breathing, circulation) and vital signs assessed & treated
    - Neurological Assessment
    - Imaging
- **Patient's condition determines next level of treatment:**
  - May be released from ER with Dr's orders
  - ICU treatment for more severe injuries that may include LOC, contusion, lesions, edema, hematoma,↑ ICP, fracture, etc.

Recovery through Rehabilitation

- For more severe TBI:
  - **ICU (Intensive Care Unit)**
    - Special Equipment: ventilator, IV tubes, catheters, NG Tube, EKG, ICP monitor, pulse oximeter, diagnostic imaging, surgery, etc.
  - **Extended Care- Rehabilitation may include**:
    - Physiatrist, PT, OT SLP, rehab. nurse, recreational therapist, neuropsychologist, aquatic therapist,
    - outpatient services, home health services, community re-entry services, independent living services, brain injury support groups, and medications

Considerations during Recovery

SIS: Second Impact Syndrome

- 2nd concussion occurs before brain has recovered from 1st concussion
- Even if 1st is mild, SIS can be catastrophic or fatal
- SIS likely to cause vascular congestion, swelling, ICP, & widespread damage
- 2 Case studies of football players who died from SIS. Click Here

Post Concussion Syndrome

- Long-term symptoms after severe or repetitive TBI's
- Memory, mood and attention deficits are common complaints
- Intellectual dullness
- Personality Changes
- Fatigue and headaches

TBI (Concussion) Prevention: Common Sense Stuff!

CHEESY ONE-LINERS

Take driving seriously

If you drink & drive you're a moron; you could kill all your neurons!

(or someone else's)

Phone Chatting = Brain Splatting

Don't be a "dumb jock"

Whether you have a bike, skates, skis or a board, wear a helmet for your GORD.

If you've already gotten one concussion, listen to the Doc, wait 'til you're healed and stop your fussing.

Violence is for Dummies

___Whether you have a crew-cut or a mullet, don't mess with fists, knives or bullets!

___

Research: RATS!

UCLA’s neurologist Christopher Giza’s experiment compared mental ability of young rats with & without concussions

Experimental Design:

- Some of rats (injured and not) placed in enriched environment until ready for test.
- Research shows enriched environments lead to ↑ cerebral cortex growth, ↑ synaptic contacts in brain, so ↑ intelligence
- Placed a hidden platform in a tank of opaque water
- 1 month post concussion, he tested their ability in the tank

RESULTS:

- The healthy rats in enriched environment were “wizards” in finding platform, while those in un-enriched environment were satisfactory.

- The injured rats in enriched environment had exactly the same poor performance regardless of the environment they had been in

ANALYSIS

- Injured rats incapable of benefiting from extra mental stimulation

- Further study through brain dissection revealed
  - Cerebral cortices of uninjured, enriched rats ↑ by 15%
  - Cerebral cortices of injured rats did not grow at all
  - Head-injured rats also showed stunted branching of dendrites

Some Follow-up Options

Egg Testing Experiment: (for lower grade levels)

Bioethics Project Idea:

1. Research a severe brain injury case study

   A. Explain the mechanism of injury, actual brain trauma, signs & symptoms, prognosis, treatment and rehabilitation, including medications.

   B. How does CNS nerve cell regeneration differ from bone or muscle cell regeneration? Explain this phenomenon as it relates to your case study.

2. Research Stem Cells

   A. What are they? Describe the variability among stem cells.

   B. Where do they come from? How can scientist obtain them?? Explain.

   C. How could brain & spine injury patients (or families) possibly benefit from using stem cells?

   D. Why is the use of stem cells for this and other uses controversial?

3. Decide whether you support or reject stem cell research for this use. Explain.