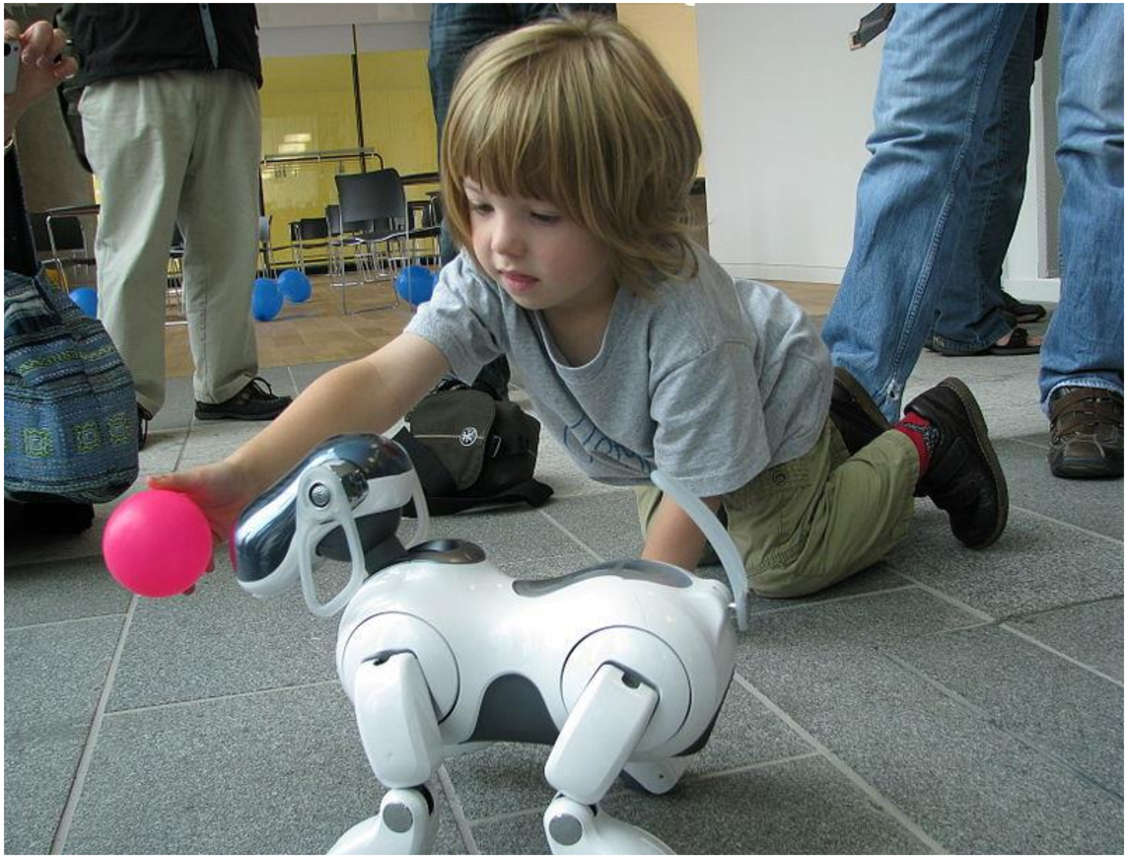
Brain is a Computer



Objective

The following slides include:

1. **A review of how a human compares to a robot, to set the context for the lesson.**
2. **Comparisons of the human brain with the robot computer.**

Days 1-3:
50 minutes each day

Brain is a Computer Quiz

1. Describe how your brain helps you command your arm to pick up a glass of juice.

2. Your brain is the controller for your body. List four functions it performs.

3. Is your brain similar to a computer? In what respects is it similar and in what respects is it not?

Brain is a Computer Quiz Answers

1. Describe how your brain helps you command your arm to pick up a glass of juice.

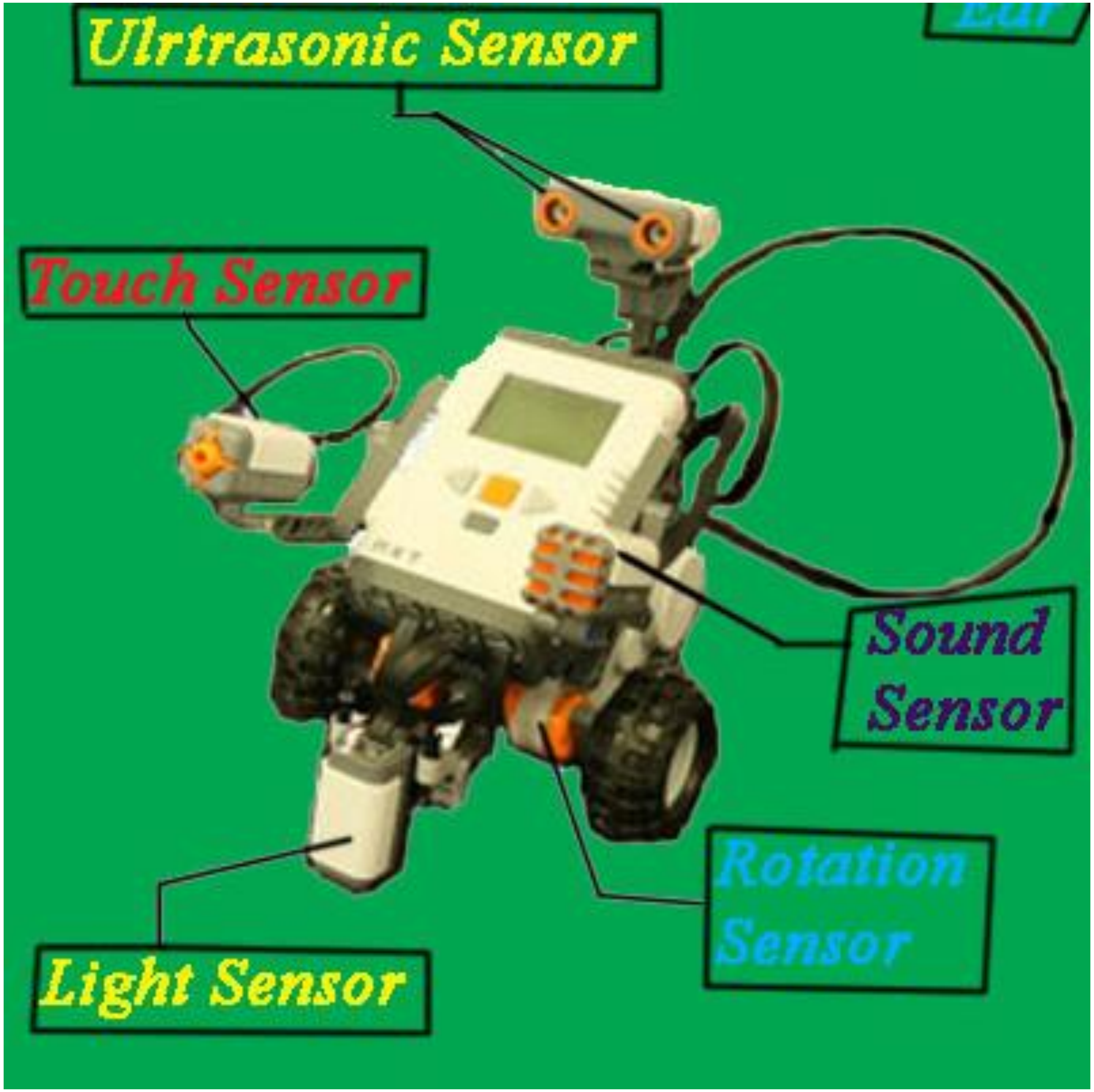
Once your brain decides to pick up the glass, neurons in your motor cortex command the muscles in your hand to move appropriately and pick up the glass. In the process, your brain uses feedback from your eyes (such as, is it going towards the glass, picking it up, etc.) and makes sure it is done as intended!

2. Your brain is the controller for your body. List four functions it performs.

Example answers: Breathing, pumping blood by controlling heart, walking, drawing, thinking, planning, memory, speaking, sensing, etc.

3. Is your brain similar to a computer? In what respects is it similar and in what respects is it not?

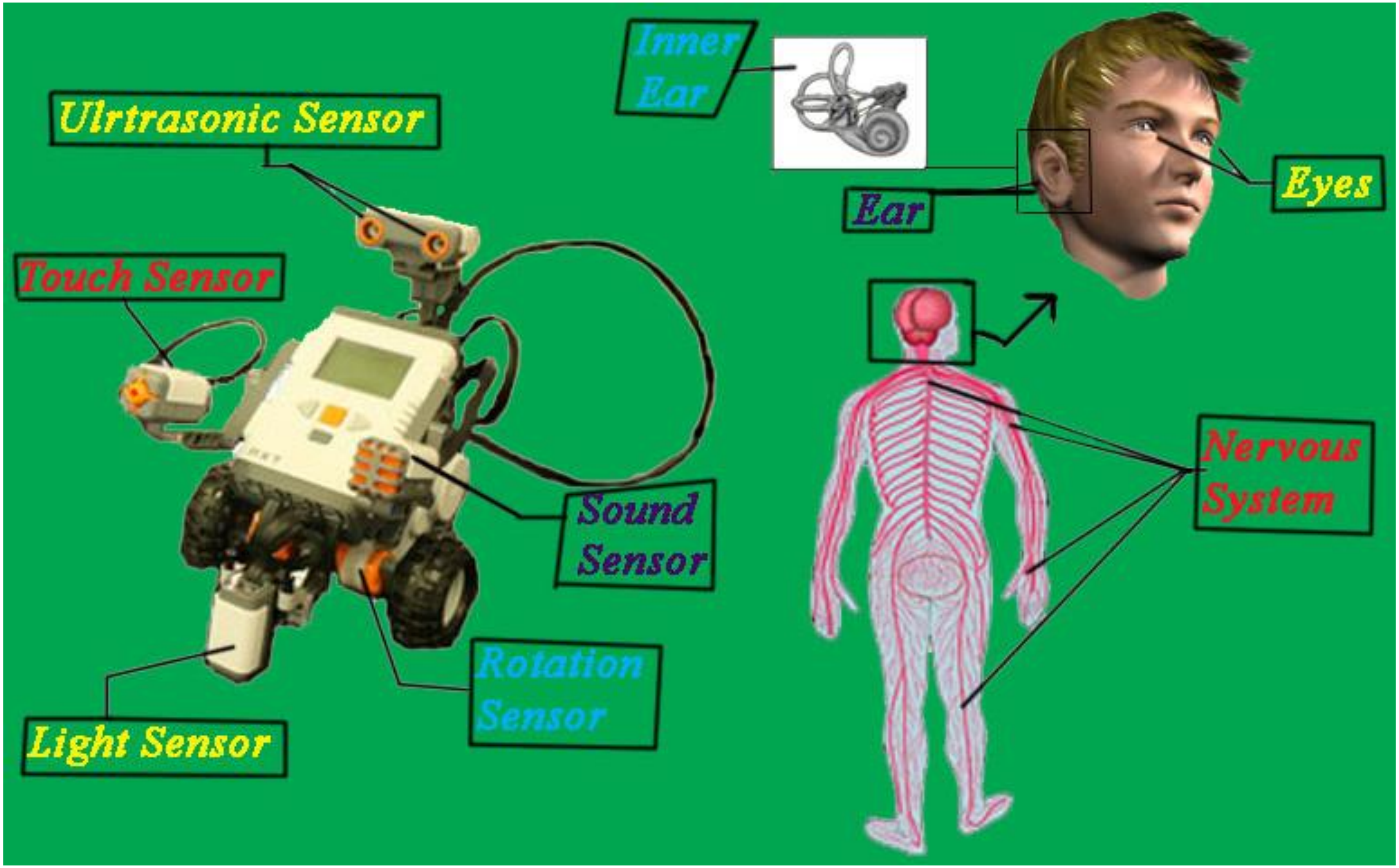
***Similarities*: makes decisions, needs energy, takes inputs, uses electrical signals, gives outputs, stores memories**
The brain processes information, needs energy (from food), takes information from senses and provides responses to muscles, using the nervous system as "wiring" for all communications. A computer has a central processing unit, needs power supply and has lots of wiring for communications with input (sensors) and output devices (motors, speaker, etc.). (Differences will be discussed later.)



Review

NXT ROBOT =
NXT brick
(computer)
+ chassis
+ motors
+ wheels
+ sensors

NXT Robot vs. Human

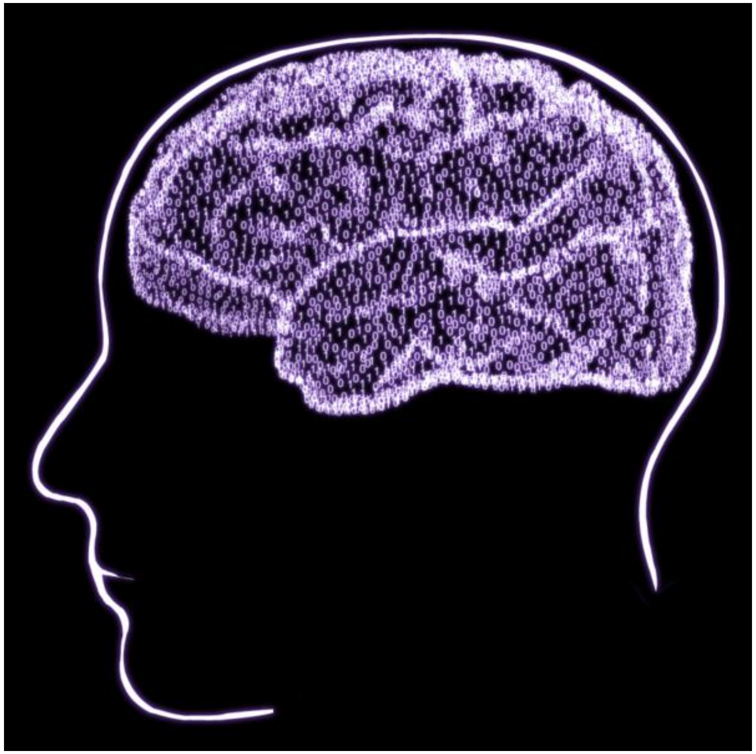


→DECISIONS/THINKING – **computer (+ wires) vs. brain (nervous system)**

→SENSING – **robot sensors vs. human senses**

→MOVEMENT – **muscles vs. DC motors (hands/legs vs. wheels)**

Let's look at the brain, and then look at the computer

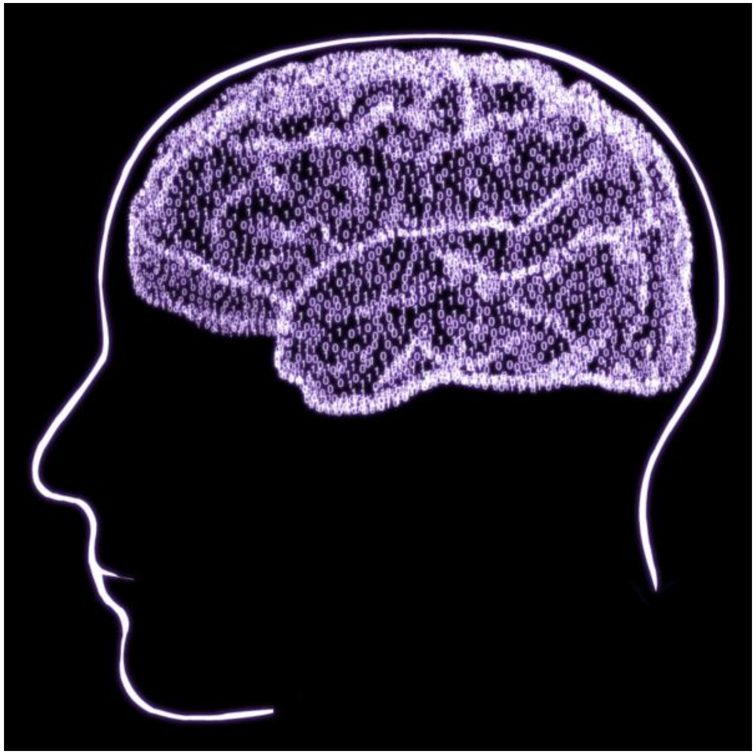


Can you list some things that your brain does for you?

Let’s look at the brain

What things does your brain do for you?

- think, plan
- memory
- speech
- move
- balance, posture
- feel emotions
- breathing, heart rate, blood pressure
- see, hear, feel, taste, smell



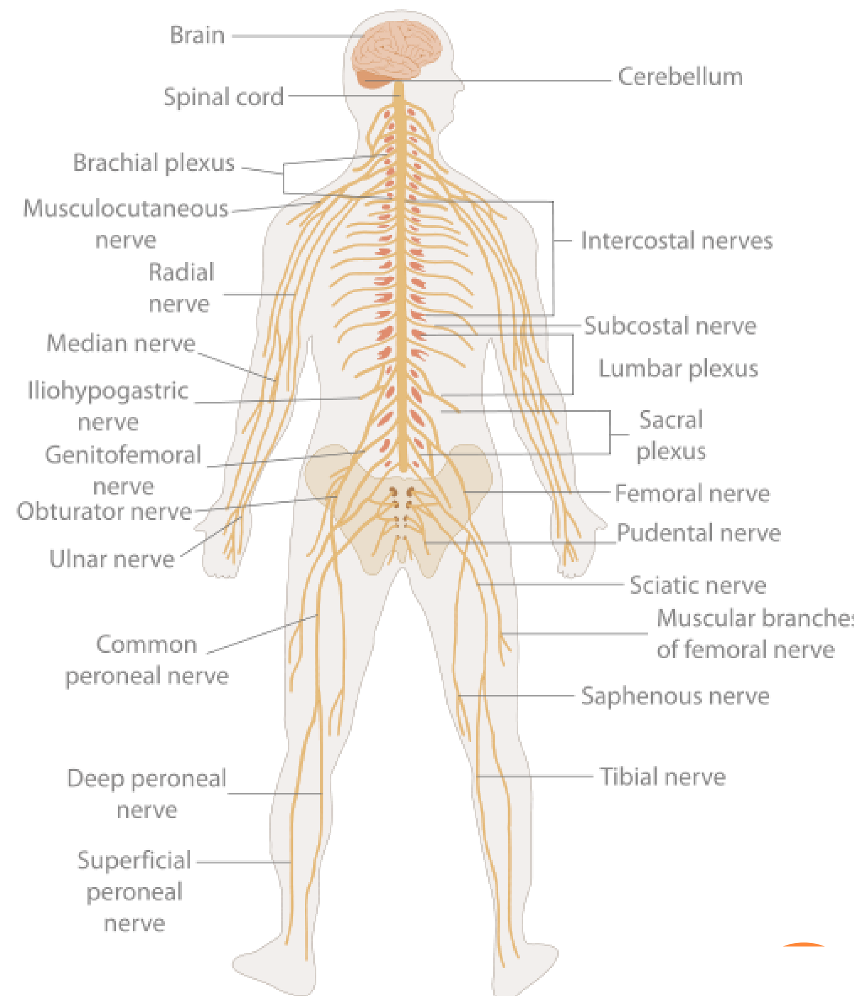
Looking at it another way, the brain…

- Makes different types of decisions for you. For instance, it tells you when you are hungry.
- Controls all your bodily functions, even without your knowing it! For instance, actions such as breathing, blinking, beating the heart and many others (that you will learn later in biology), are all controlled subconsciously by the brain all the time.
- Learns new things, such as riding a bicycle, swimming, languages, playing instruments, games or sports, and lots and lots of such skills.
- Sensors provide continuous input to the brain through your eyes, ears, nose, skin and mouth. It must "understand" what the sensors tell it and make decisions. For example, run when you see a snake!
- It does all this using about 100 billion neurons (humans) that talk t each other – right now we don't really know how!

Human Nervous System

- The nervous system is the set of wires (called nerves) that allow the sensors to talk to the brain, and the brain to talk to the muscles
- The nervous system is like two sets of one-way streets

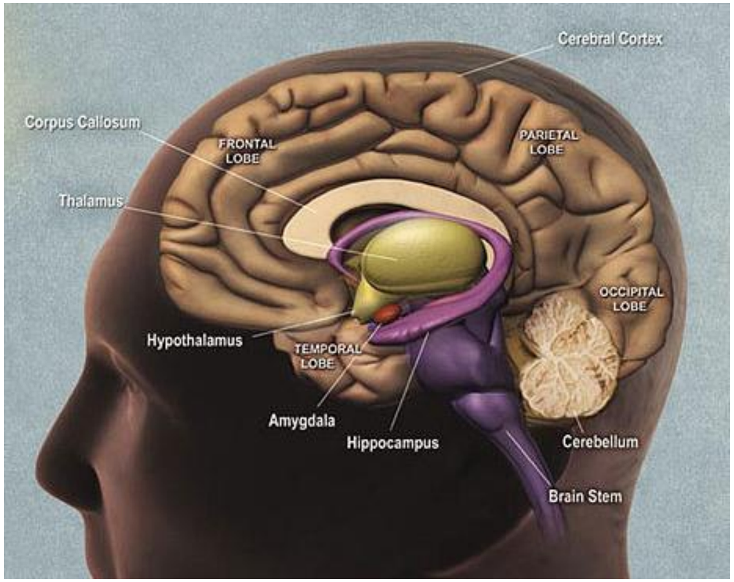
  - Through one set of nerves, the sensors tell the brain what they sense
  - Through another set of nerves, the brain tells the muscles to contract and causes the body to move



How does this happen in a robot?

Do you know your brain?

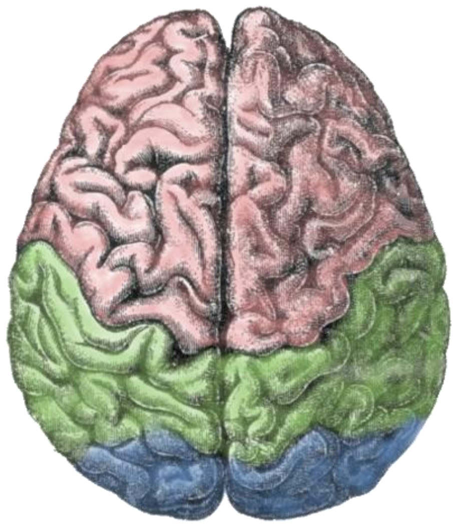
- The brain is the decision center of the body
- How does the brain and nervous system move our hands?
  - When a hot object is touched, the touch sensors are activated
  - Nerves transmit information from the touch sensors to the brain
  - The brain decides to move the arm back to protect the finger
  - The brain sends signals along nerves to muscles to move the arm
  - The muscles then move the arm
  - (We will look at details later)

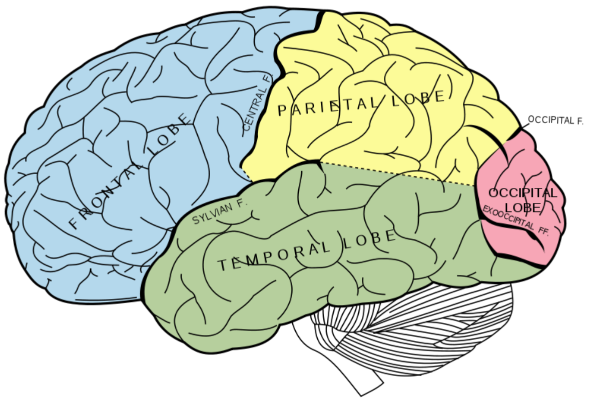


Let's look at the structure of this "human computer." ➔

Human Brain?

- The human brain looks like a cauliflower and is about the same size.
- It is divided into right and left hemispheres.
- Human brains are divided into four lobes.

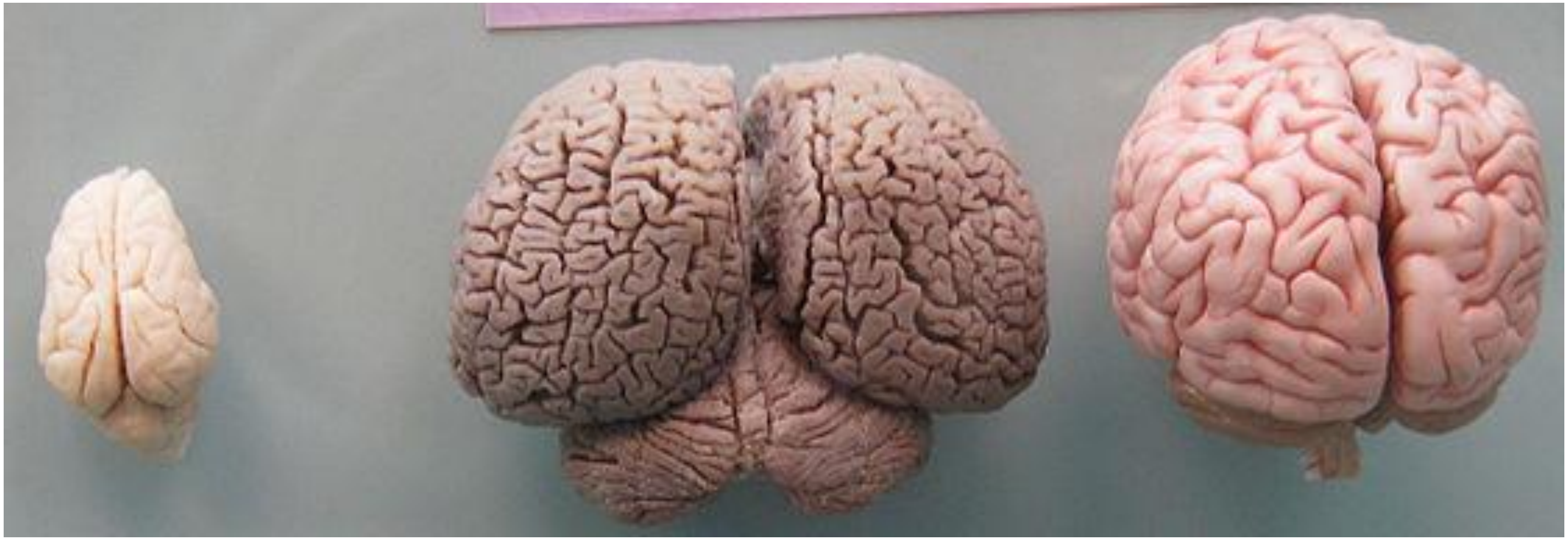




cerebellum

The brain is not colored like this (usually it appears gray); color is added in the drawings just to distinguish the lobes.

Brain Sizes

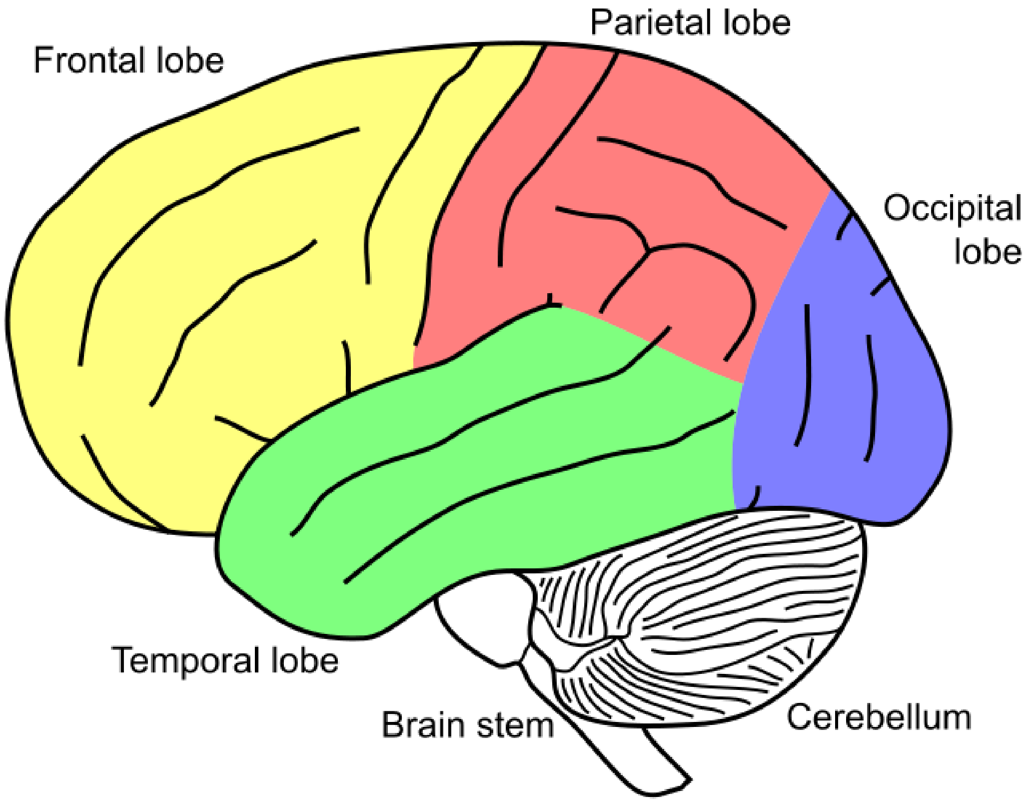


Scale model of brains from:

wild pig (left) bottlenose dolphin (middle) human (right)

An adult human brain weighs ~ 3 pounds.

Four Lobes of the Brain



Check out details about the different lobes with a moving cursor at this website:

http://thebrain.mcgill.ca/flash/d/d_01/d_01_cr/d_01_cr_ana/d_01_cr_ana.html#1

Worksheet

1. Make a sketch of the human brain and label the four lobes.

2. How much does an adult brain weigh?

DAY 2

In this lesson, we will only consider
how our brains help us move

Q: Where does the idea/plan to move begin?

A: From a brain region called prefrontal cortex, which is located in your frontal lobe

- Tasks the prefrontal cortex helps us with:
  - planning
  - problem solving
  - complex thought
  - control
  - inhibition

How do we move?

- **Most of our movements are in our control and we are aware (conscious) of them**
- **Reflexes, such as a knee jerk, are movements that we are not aware of and cannot control**
- **Let's consider movements that we consciously control…**

How do we move?

- Most of our arm and leg movements are conscious decisions
- First we plan a movement in our brain (using our prefrontal cortex) to move our leg
- The prefrontal cortex then sends a signal to the motor cortex, which in turn sends a signal via the nervous systems to the leg
- Finally, the muscles in the leg get the signal and perform the movement

Movement Activity

Complex control occurs in movement

- While sitting, raise your right leg and rotate your foot clockwise from the hip, tracing circles in the air
- While continuing to do so, trace the number "6" in the air with your right hand
- Now look at your foot: it has started turning in the other direction, even though you never consciously told it to!
- You will study in later grades about the complex control that occurs in movement, but now you know it does happen!

This happens partly due to the normal difference in height between hand and foot. That difference, in conjunction with gravity and the Earth's rotation, is enough to affect the body's highly sensitive limb rotation mechanisms.

Parts of the brain that help us move

- motor association cortex
- primary motor cortex
- basal ganglia
- cerebellum

How do we move?

Waving Goodbye

- This action needs:
  - Thought – I need to wave bye
  - I want to wave bye
  - Start the motion to wave bye
  - Make sure the hand goes back and forth in bye
  - Stop the hand waving

How do we move?

- **The thought and desire to wave goodbye comes from the prefrontal cortex**
- **Movement starts from the primary motor cortex**

How do we move?

- Primary motor cortex
  - Initiates the voluntary movement
  - If you want to wave goodbye, this part of the brain starts the action
  - Different parts of the body are represented in the motor cortex upside down with the knees on top and the legs on the medial side

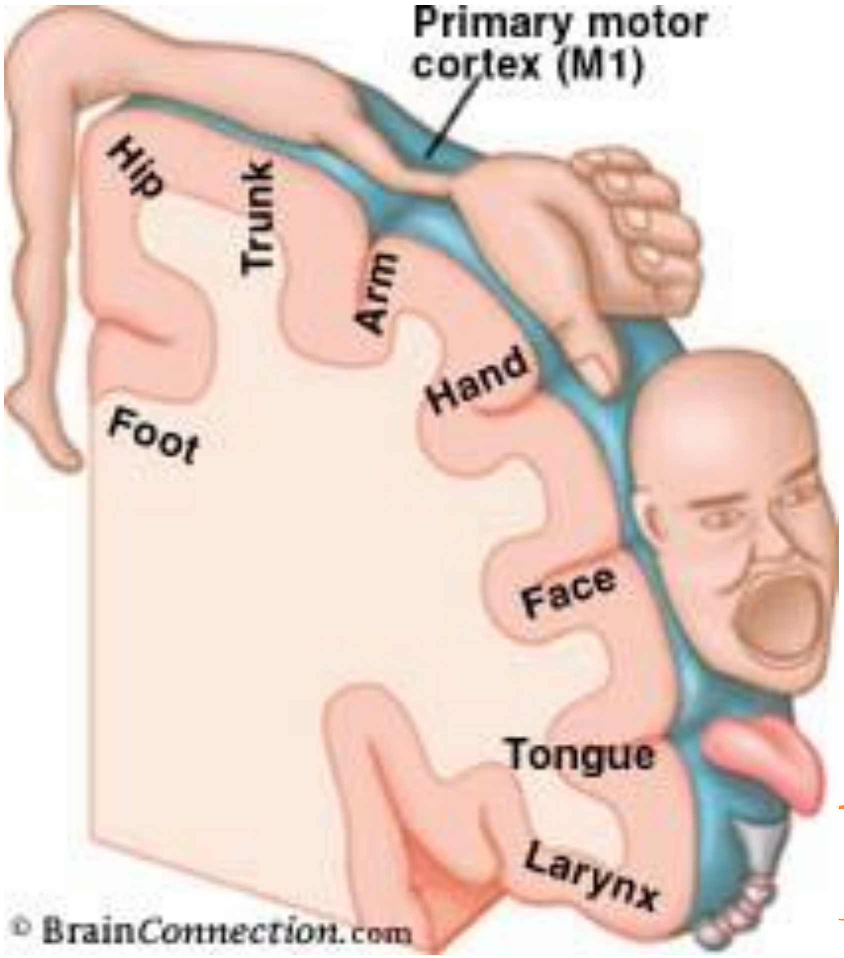
Look at this website to see how the motor/sensory homunculus works

http://www.cs.uta.fi/~jh/homunculus.html

Sensory/Motor Homunculus

Mapping of the different body parts in the brain

- A sensory/motor homunculus (important medical term!) is a pictorial representation of the anatomical divisions of the parts of the human cortex directly responsible for the movement and exchange of sense and motor information with the rest of the body
- For example, taste information from your tongue goes to a very specific part of the brain, as shown by the homunculus



How do we move?

- Motor association cortex – coordination of complex movement of waving
- The primary motor cortex starts the wave and the motor association cortex coordinates the movement of the other muscles as you wave

How do we move?

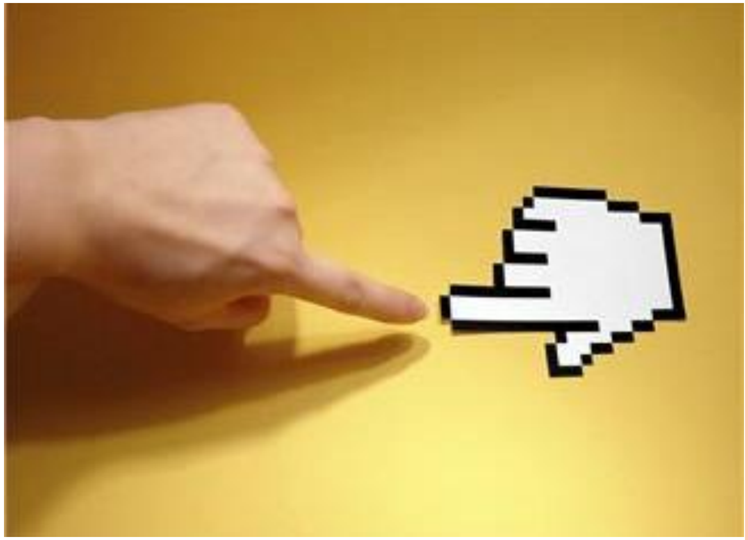
- In Parkinson's disease, the basal ganglia are damaged and a person has difficulty starting movement
- It would be difficult to make the hand start the movement to wave goodbye

How do we move?

- **Cerebellum**
  - **Important in regulating movement**
  - **Improves coordination of new movements by calming certain neural pathways that would otherwise impede the fluidity of the movements**
  - **When waving goodbye, helps make the hand move smoothly in space and not go too far on either end**

How do we move?

- When someone tries to touch his/her nose, the cerebellum provides the information on the distance the hand needs to travel before touching the nose
- Alcohol causes the cerebellum to not function correctly. When the cerebellum does not function correctly, basic movements, such as walking and balancing, become difficult. Police check for difficulty in basic movements to determine whether a person is drunk (coordination impaired)



Brains vs. Computers

- **Both make "decisions," for example, the brain decides when to walk; a computer decides what to display on the screen**
- **Both need "inputs" from sensors to make decisions.**
  Can you think of examples?
- **Both process "electrical signals."**
- **Both have the capacity to store "memories." As a child your brain learns how to walk/swim and stores the procedure in the brain, and it replays them when you walk/swim. Similarly, a computer remembers whatever it has been programmed to do.**
- **Other?**

What are some similarities between brains and computers?

What is a computer?

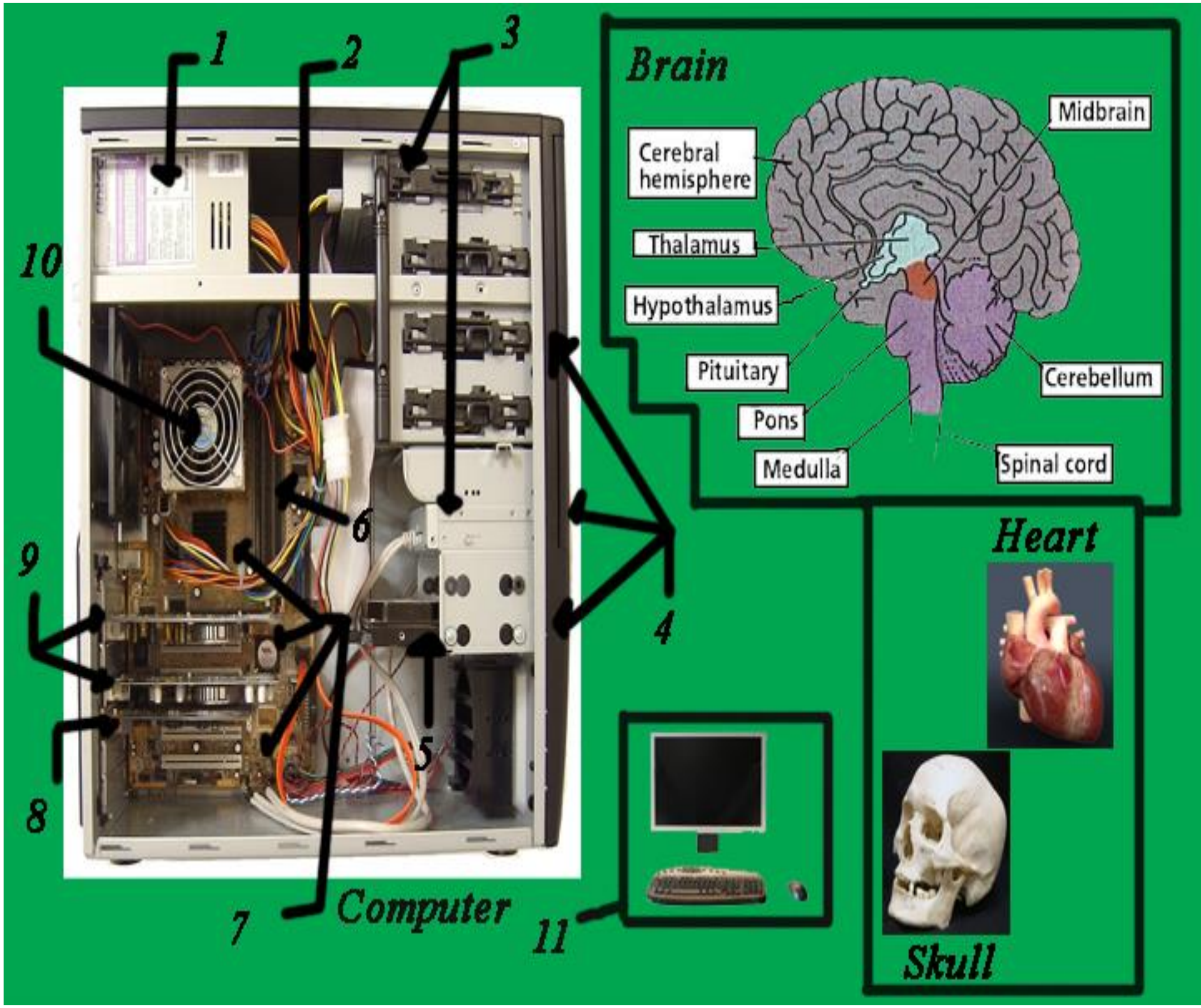
A computer takes data from input devices such as a keyboard or mouse, processes the information using its "brain," and then provides the OUTPUTs via devices, such as a monitor or speaker

What does a computer do?

- Computers are getting smarter every day. But they are not as smart as your brain right now.
- Computers just follow "programs" that humans write and do what the programs tell them to do. So, if we write advanced programs (you will learn in later grades how to write software programs), we can make the computer do a lot of fancy things.
- Computers store data and have memory.
- Computers do some calculations faster than your brain.
- As mentioned earlier, brains do many more tasks than a computer.
- Computers have limited numbers of sensors compared to humans. You have about 50,000 touch sensors on your thumb alone, and millions throughout your body. The brain has to make sense of all these sensor inputs. A computer would be over-loaded if it had to handle so many sensors! Humans do it easily.
- But computers are improving!

What are some differences between brains and computers?

Questions: Computers vs. Brains



1. What human organ acts as the power supply for the brain? For a computer?
2. Look at all the wires in the computer. What is the equivalent in our bodies?
3. What devices provide inputs to the brain? What are the equivalents in a computer?
4. What devices provide output from the brain? What are the equivalents in a computer?
5. What houses and protects the brain? What [illegible] equivalent in a [illegible]r?

Comparing Functions

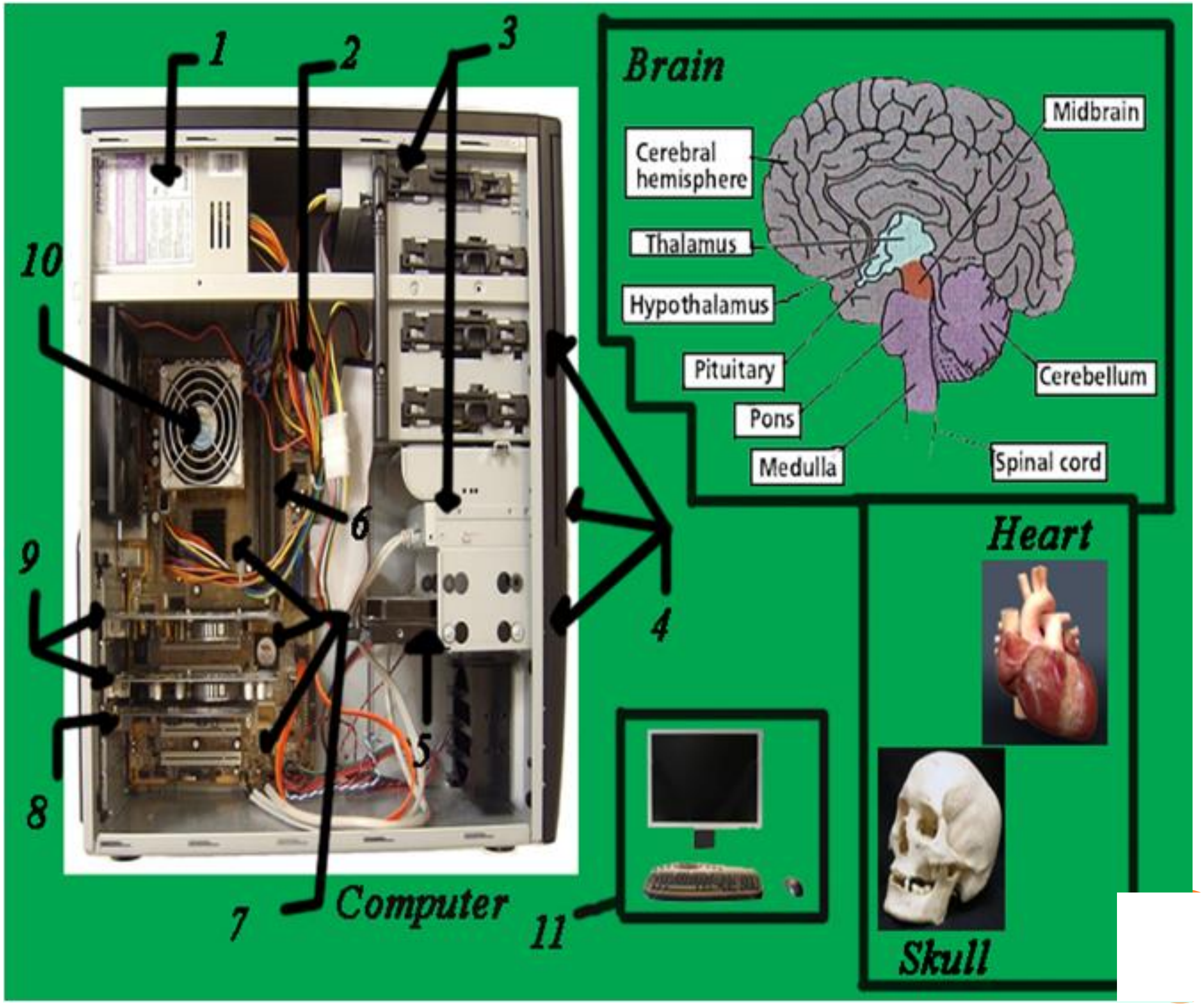
1. The heart supplies power for the brain to function = power supply / computer battery (1)

2. The spinal cord/nervous system relays signals from inputs to the brain = computer wiring (2)

3. Our senses are the "devices" that provide input to the brain = keyboard, drives (floppy / CD / DVD) (3), networking cards (8), fingerprint and retinal scans provide computer input

4. Our mouths (for speech) and limbs (for movement) provide output from the brain = monitor and speakers (11) provide computer output

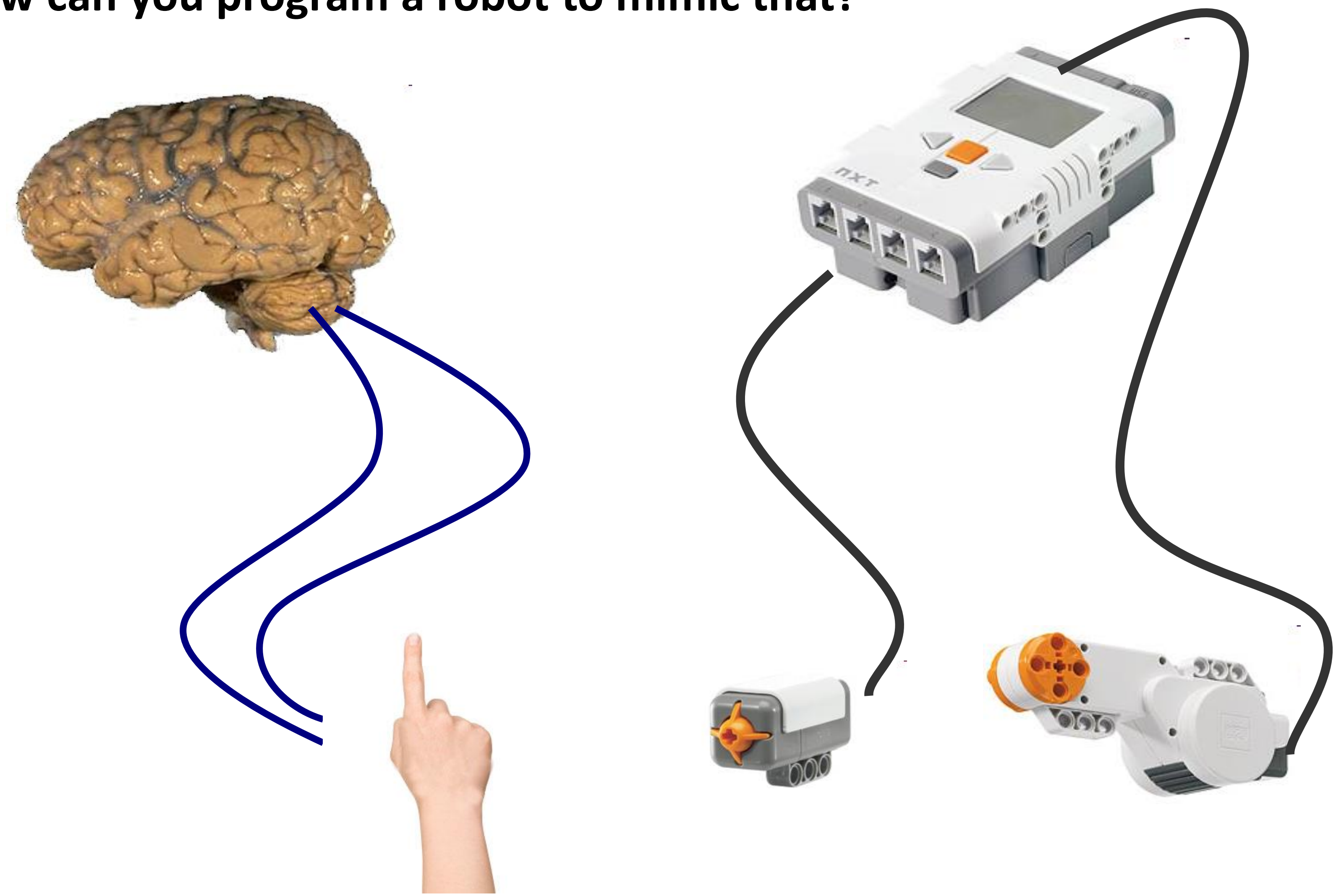
5. Our skulls protect the delicate brain = case (5) protects vulnerable computer parts



Comparison

How do you jerk your hand back when you touch something really hot?

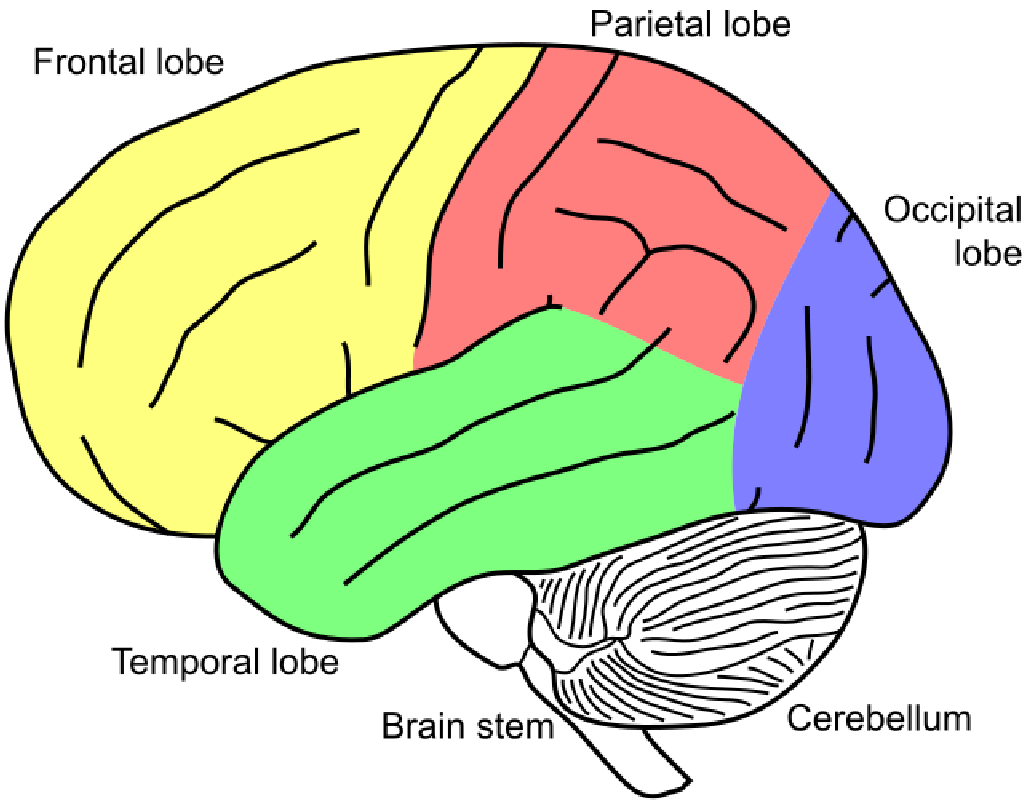
How can you program a robot to mimic that?



How you sense something by touch?

- When you touch something, the sensory organs at the tips of your fingers send signals to the brain through nerves
- These signals travel to the brain through the spinal cord. All the signals related to human body must travel through the spinal cord
- Thus, the spinal cord can be referred to as the common pathway for brain signals
- The brain processes the information and then sends its decision back through the same neural "wires" to the muscles in your hand to react appropriately
- **Example:** When you touch a hot object, the nerves carry the signal to the brain and the brain decides it is bad for you, and immediately sends back a signal to the muscles in your hand to withdraw the fingers. This signal transmission takes place in a fraction of a millisecond

Touch sensors on our skin

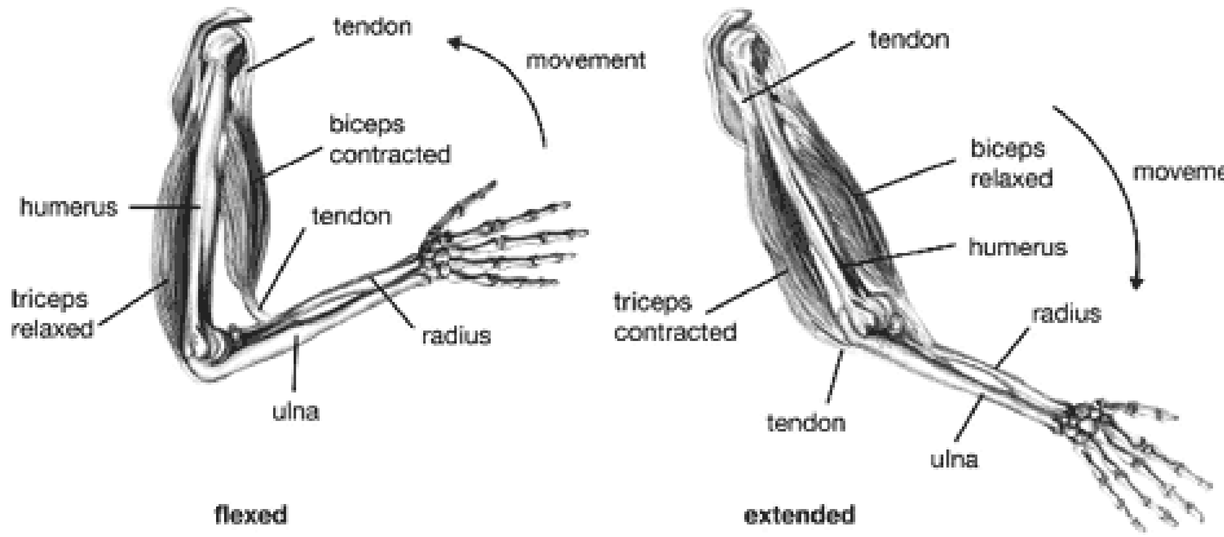


Watch "The Sensory Cortex and Touch" video (1:08 min):

http://www.youtube.com/watch?v=IC3YTJNu0Ec&feature=related

How do muscles help us move?

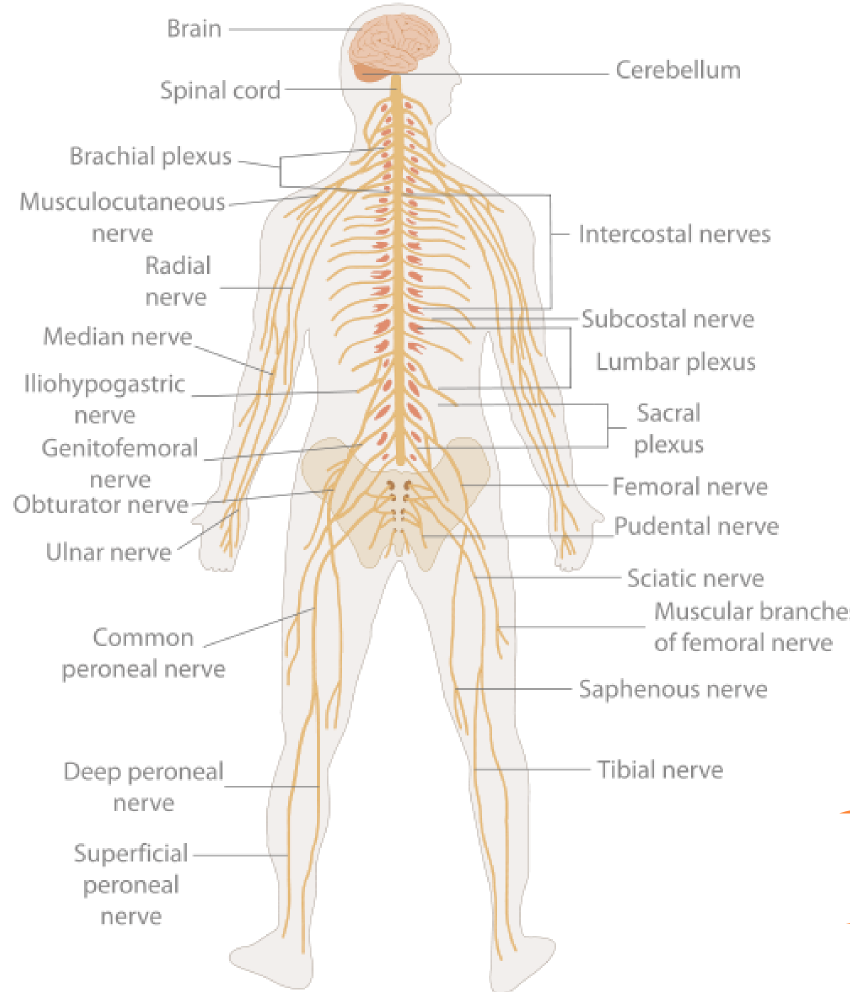
Example:
bending your elbow



- **Muscles help us move by contracting, which causes them to pull on our bones using connections called tendons. These contractions are caused by signals sent by the brain through the nervous system to the muscles**
- **To bend the elbow, your biceps muscle contracts, which causes your triceps muscle to relax. The biceps muscle pulls on the inside of your forearm, pulling it upward and bending your elbow**
- **To straighten your elbow, the triceps contracts, causing your biceps to relax. The triceps pulls on the outside of your forearm, causing your arm to straighten**
- **Similar analysis applies to moving your legs. Walking requires the use of about 200 muscles, including the small ones**

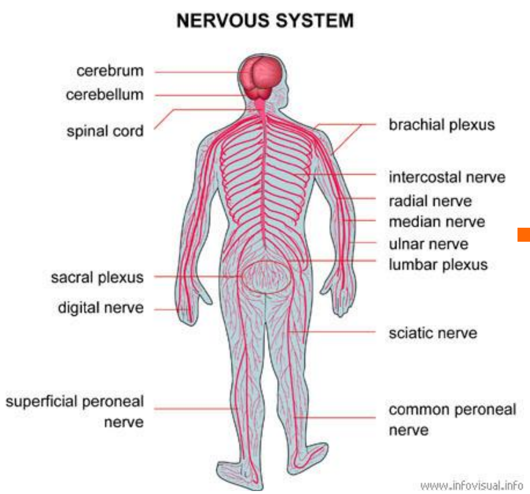
How does your hand jerk back when touching a hot object?

Sensors on your finger take the information about how hot it is to the spinal cord via nerves (all part of your "nervous system")

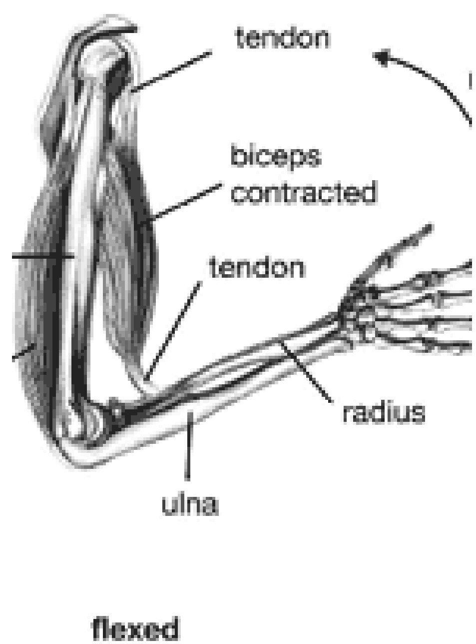


How does your hand jerk back?

Your “nervous system” decides that it is too hot and orders the muscles of your hand to pull back the finger



contract biceps

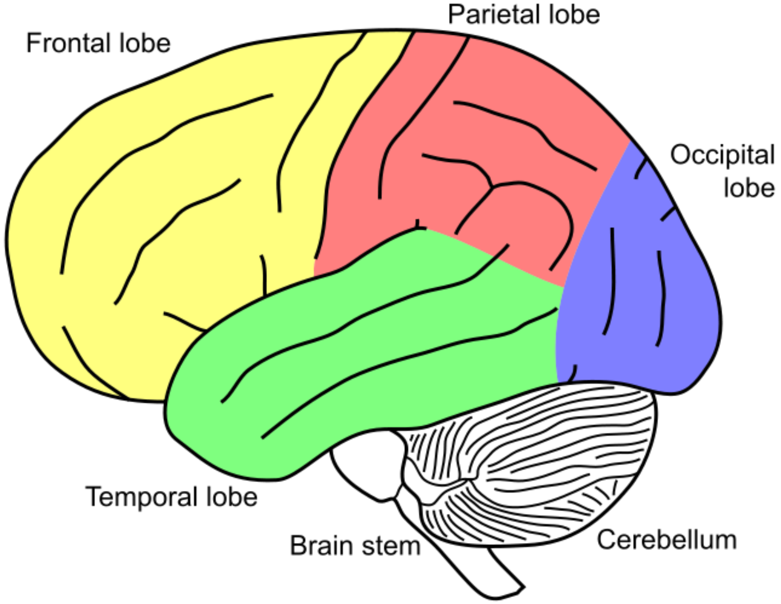


finger moved back

DAY 3

Review: Do you know your brain?

- The brain is the decision center of the human body
- How does the brain and nervous system move our hands?
  - We get information from sensors
  - When you touch something, sensors obtain data about the object, such as its temperature or texture
  - Based on that input, our brains tell the muscles in our hands to move appropriately
  - How is this done?



Now let us look at how brains are similar to computers ➔

Review: Brains vs. Computers

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Review: Comparing Functions

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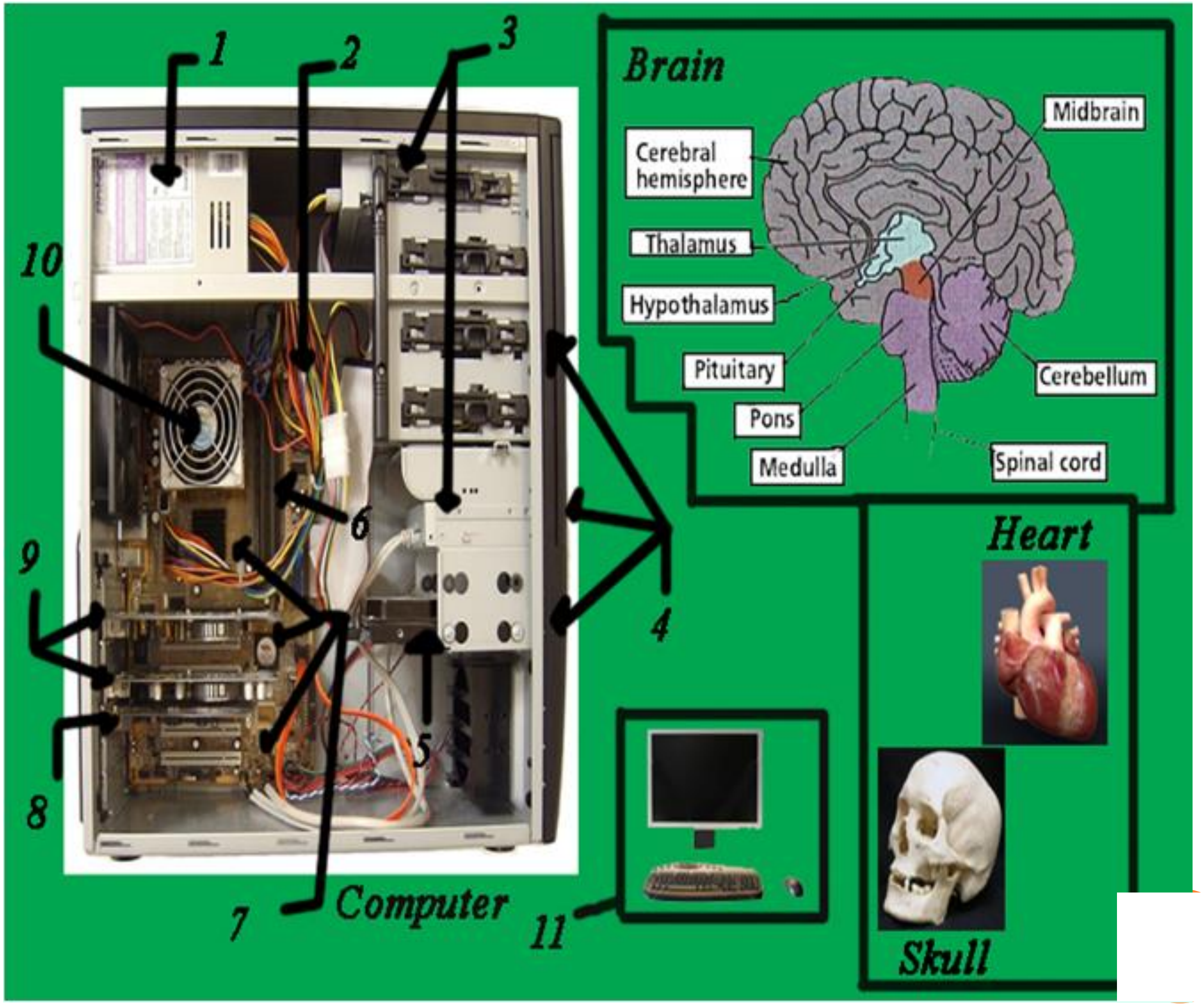

Stimulus-to-Response Framework

stimulus → sensor → coordinator → effector → response

touch → pain receptor → nervous system → muscle → movement

***Looking at the sequence of steps above, this is what happens when you touch something hot*: The stimulus is touch, the sensor is the temperature/pain receptor on your finger that senses it and relays it to the nervous system (spinal cord and brain), which is the coordinator. The coordinator makes the decision of how to react, and then commands the hand muscles (acting as the effector) to jerk back quickly.**

The framework takes us from stimulus (touch) to response (hand movement)

Your task:

Sketch out how the stimulus-to-response sequence might be implemented in a robot. Identify all the components as in the example listed above.

DAY 3 (post-lesson assessment)

Brain is a Computer Quiz

1. Describe how your brain coordinates conscious movement, such as moving your hand to pick up a glass of milk.

2. How is your brain similar to a computer? Identify which parts of brains and computers implement similar functions?

3. Describe how your brain causes your hand to jerk back when your finger touches a hot object.

DAY 3 (post-lesson assessment)

Brain is a Computer Quiz Answers

1. Describe how your brain coordinates conscious movement, such as moving your hand to pick up a glass of milk.

The prefrontal cortex decides that it has to pick up the glass. Then, it passes that desire to the primary motor cortex that coordinates the activity. It sends information to the correct muscles to move, and makes them move with the assistance of two other structures: basal ganglia and the cerebellum.

2. How is your brain similar to a computer? Identify which parts of brains and computers implement similar functions?

Both make decisions. Both take inputs from sensors, for example, from touch sensors or finger sensors. Both provide outputs to actuation devices, for example, to move a muscle or a motor.

3. Describe how your brain causes your hand to jerk back when your finger touches a hot object.

Sensors on your finger take the information about how hot it is to the spinal cord via nerves (all part of your “nervous system”). The “nervous system” decides that it is too hot and orders the muscles of your hand to pull back the finger.

Vocabulary

computer A human-created electronic device that processes data, performs mathematical and logical calculations, displays graphics, and helps you connect to the internet.

robot A mechanical device that sometimes resembles a human and is capable of performing a variety of often complex human tasks on command or by being programmed in advance.

sensor A device that converts one type of signal to another. For instance, a tachometer displays the speed that your car is traveling.

emotions Feelings. Such as feelings of happiness, sadness or fear.

homunculus A drawn mapping that shows where the various regions of the body (finger, nose, etc.) are connected in the brain.

stimulus Something that causes a response.

Image Sources

Image 1a: child and robot dog; source: 2008 Stuart Caie, Wikimedia Commons
http://commons.wikimedia.org/wiki/File:AIBO_ERS-7_following_pink_ball_held_by_child.jpg

Image 1b: x-ray like image showing shoulders, spinal cord and brain in a head; file name: MP900438746-225x300.jpg; source: AZ Dept. of Health Services Director's Blog http://directorsblog.health.azdhs.gov/wp-content/uploads/2013/02/MP900438746.jpg

Image 2: Picture of the brain; file name: CCN.png; source: http://commons.wikimedia.org/wiki/File:CCN.png

Image 3: Nervous system; file name: TE-Nervous_system_diagram.svg.png; source: theEmirr, Wikimedia Commons http://commons.wikimedia.org/wiki/File:TE-Nervous_system_diagram.svg

Image 4: Side view drawing of human brain with parts identified; file name: NIA human brain drawing.jpg; source: National Institute for Aging, Wikimedia Commons {PD}
http://commons.wikimedia.org/wiki/File:NIA_human_brain_drawing.jpg

Image 5a: Human brain with four lobes identified; file name: Gray728.svg; Source: Mysid, Wikimedia Commons
http://commons.wikimedia.org/wiki/File:Gray728.svg

Image 5b: Human brain showing left and right hemispheres; file name: Płaty mózgu.png; source: Wikimedia Commons http://commons.wikimedia.org/wiki/File:P%C5%82aty_m%C3%B3zgu.png

Image 6: Brain sizes; file name: GeTursiops_truncatus_brain_size.JPG; source: Boksi, Wikipedia
http://en.wikipedia.org/wiki/File:Tursiops_truncatus_brain_size.JPG

Image 7: Four lobes of the brain; file name: Gehirn, lateral - Lobi eng.svg; source: 2007, NEUROtiker, Wikimedia Commons http://commons.wikimedia.org/wiki/File:Gehirn,_lateral_-_Lobi_eng.svg

Image 8: Child sitting next to a stack of comic books and reading; file name: MP900232988.jpg; source: Microsoft clipart http://office.microsoft.com/en-us/images/cartoons-CM079001908.aspx#ai:MC900232988

Image 9: Skating figure; file name: MH900149674; source: Microsoft clipart:
http://office.microsoft.com/enus/images/results.aspx?qu=skating#ai:MC900149674|mt:0|

Image Sources (continued)

Image 10: Ballerina dancing; file name: MP900405192.jpg; source: Microsoft clipart: http://office.microsoft.com/en-us/images/results.aspx?qu=movement&tl=3#ai:MP900405192

Image 11: Beach volleyball ; file name: MP900430614.jpg; source: Microsoft clipart: http://office.microsoft.com/en-us/images/sports-CM079001966.aspx#ai:MP900430614

Image 12: Emoticon saying goodbye ; file name: MP900442024.jpg; source: Microsoft clipart: http://office.microsoft.com/en-us/images/results.aspx?qu=bye#ai:MC900442024|mt:0

Image 13: Two children side by side; file name: MP900423023.jpg; source: Microsoft clipart: http://office.microsoft.com/en-us/images/results.aspx?qu=up+side+down&tl=3#ai:MP900423023

Image 14: Picture of the motor homunculus; file name: Homunculus_two.html; source: PositScience via National Public Radio http://www.npr.org/templates/story/story.php?storyId=101960403

Image 15: office bye; file name: MP900060145.jpg; source: Microsoft clipart: http://office.microsoft.com/en-us/images/similar.aspx#ai:MC900060145

Image 16: children with raised hands; file name: MP900425487.jpg; source: Microsoft clipart: http://office.microsoft.com/en-us/images/results.aspx?qu=child+raising+hand&tl=3#ai:MP900425487

Image 17: Man in a suit demonstrating the body language for thinking; file name: MP900150563.jpg; source: Microsoft clipart: http://office.microsoft.com/en-us/images/emotions-CM079001910.aspx#ai:MC900150563

Image 18: hand and computer icon; file name: MP9004383321.jpg; source: Microsoft clipart: http://office.microsoft.com/en-us/images/results.aspx?qu=hand#ai:MP900438332

Image 19: Components of a computer; file name: pantalla plana.jpg; source: 2005 Nick Gray, Wikimedia Commons {PD} http://commons.wikimedia.org/wiki/File:PANTALLA_PLANA.JPG

Image 20: Arm muscles flexed and extended; file name: figure3-2.gif; source : National Institutes of Health http://science.education.nih.gov/supplements/nih6/bone/guide/lesson3b.htm