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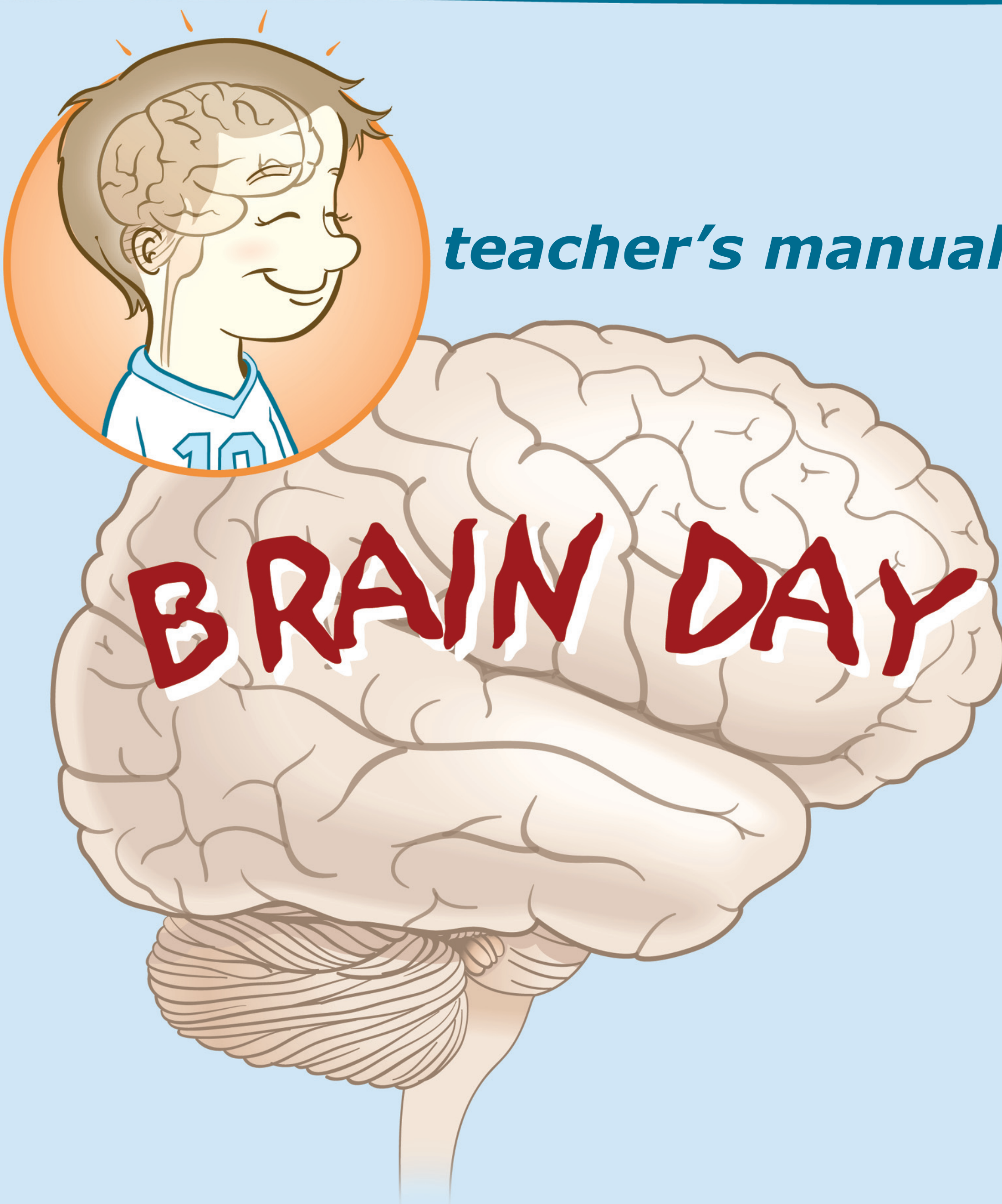
teacher's manual

BRAIN DAY



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NEURON

[Background Information]

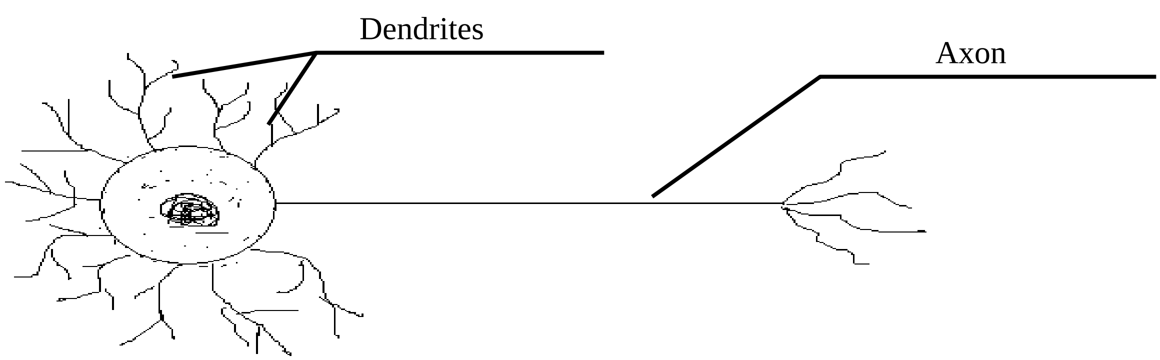
The principle cellular elements of the nervous system are neurons. Neurons are information-processing and signaling elements. They transmit messages to each other electrically and chemically. Electrical signals are used to convey messages rapidly from one part of the neuron to the other. Chemical messengers are used to carry information between neurons. Most neurons have a series of branches called dendrites. Dendrites receive information from other neurons. One long cylindrical process called the axon gives rise to a series of terminal branches that form connections (or synapses) with other neurons. So, messages are conveyed from axon to dendrites.
There are different kinds of neurons as well. There are sensory neurons (neurons that are sensitive to certain stimuli, i.e. touch or temperature), motor neurons (neurons that end directly on muscles), and inter-neurons (neurons that connect other neurons in the CNS).

[Neuron Lesson Guideline]

1) Neuron Anatomy: (~ 10 minutes)

- → *Explain that our brains are made up of billions of cells called neurons! Begin with an overview of the structure of the neuron.*
- → *Label the neuron diagram. Explain the difference between axons and dendrites.*
- → *Then show the* ***colourful neuron acetate*** *of schematic neurons.*

The human brain is made up of 100 billion cells called ***neurons!*** Neurons are different from other cells in our body because they have specialized branches protruding from the central body of the neuron (also known as the cell body or soma) on either side. Each neuron carries and passes signals from one neuron to the next. The branches that receive information from other neurons are called the ***dendrites.*** The extensions that pass signals to other neurons are called the ***axons.*** No other cell in the body has these specialized signaling extensions!



2) Neuron Activity: (~15 minutes)

- → *You will need: pencil, paper*
- → *This purpose of this activity is to demonstrate neuronal signaling.*
- → *Show that neurons are like message conveyers from the brain to our effectors (or muscles) and also from our muscles back to our brain. Messages can go either way.*
- → *Prepare a few notes on pieces of paper. Make 2 rows of students standing in a line (one behind the other). Explain that each person in the chain is a "neuron" sending signals to the next person. Give the note to the first person in each line. When the note reaches the last person, he/she can read the message.*
- → *See which groups can send the signal the fastest.*

→ *Ask: Does the number of "neurons" in a chain affect the signal speed? What else do you think can affect the signaling?*
NOTE: You can also try this activity without the use of notes. Substitute the note passing with squeezing hands if you wish.

→ *The signaling speed is affected by the **number of neurons** in the chain. I.e. if there are more neurons in a particular pathway, then the time it takes for the signal to reach it's final destination (i.e. a muscle to contract) will take longer. Our reflexes our mediated by the shortest pathways there are in our body. These pathways typically consist of one or two neurons, monosynaptic or disynaptic pathways respectively.*

→ *The signaling speed is also affected by the **TYPE** of message. If the message is very simple, it will be sent the fastest (i.e. withdrawal reflex from touching a hot stove is very quick and occurs faster than you can say "ouch!" This is because our response is reflexive and the message is simple: PAIN!) If the message is more complex, it will take longer to be processed. (I.e. if we walk down the street and see a particular face that we sort of recognize, sometimes it takes a long time to figure out who that person is before we say "hello". This is because the message is not a reflex; it is complex and involves the memories of that person and the perception of their facial features at that instant as well.)*

3) Let's talk neurons! (~ 3-5 minutes)

→ *Wrap up this section with a few fun facts!*
→ *Bring home the message: the best cure for neuronal/brain damage is PREVENTION*
→ *Ask the kids what kinds of thing they can do to prevent accidents?*
** You can wear your helmet (and wear it right), look both ways before crossing, wear a seatbelt..*

Neurons are one of the most specialized cells in the human body. The fastest neurons can send signals up to 120 metres per second! Neurons that signal things like sharp PAIN send the message quickly. Other neurons, like those sending temperature signals, send signals up to 2 metres per second.
Our skin cells and hair cells always grow back. A broken arm or bruise can recover but damaged neurons cannot. The best cure for brain damage is PREVENTION!

ANATOMY

[Background Information]

The nervous system is divided into two parts: the peripheral nervous system (PNS) and the central nervous system (CNS). The CNS consists of our brain and spinal cord, while the PNS constitutes the collection of spinal and cranial nerves whose branches extend to all parts of the body. These nerves convey messages from the CNS.

The brain itself has many subdivisions and is composed of the cerebrum (the two massive hemispheres on the top of the brain), the cerebellum, and the brainstem (part of the CNS that lies between the cerebrum and the spinal cord. The lobes or divisions of the cerebrum are discussed below. Note that what distinguishes humans from other primates is our enlarged cerebrum. Our cerebrum, or neocortex is the most evolved cortex in mammals. You can ask the children why we are capable of language, planning, fine motor movements, personality, and etc, while other mammals are not. It is because we have a highly developed neocortex!

[Anatomy Lesson Guideline]

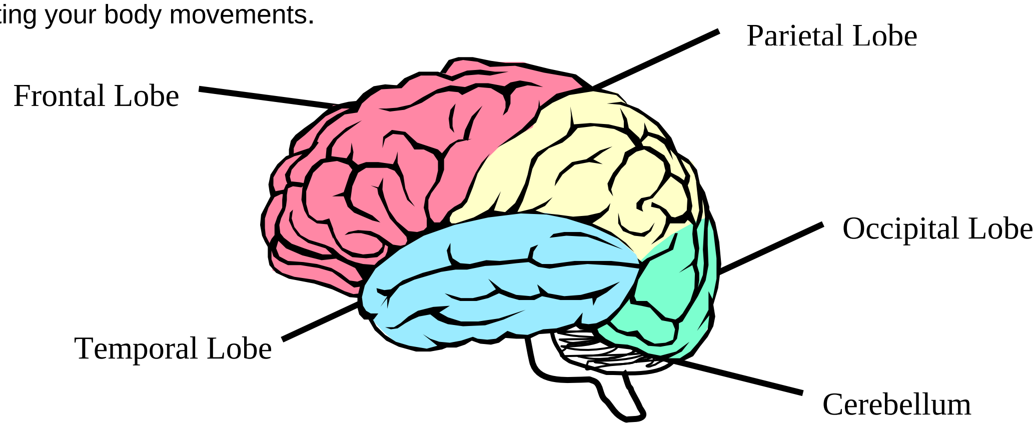
1) Introduction: (~1-2 minutes)

→ *You will need: the **brain anatomy acetate** provided*
→ *You can start by asking questions like "So, we know the brain is made up of billions of little cells called neurons, but what exactly does the brain do?"*
→ *Then proceed to naming and describing the lobes (please give the students a chance to label).*

2) Naming the lobes: (~ 15 minutes)

- → *The kids will need: pencils*
- → *Begin with an overview of the 4 major lobes (or functional areas) of the brain.*
- → *Ask a student volunteer to come up and help you identify the lobes of the brain on Mr. Balloon Head (balloon and cut-out lobes, and tape are in the brain box)*
- → *Try to ask questions and promote thinking about each lobes' functions from the perspective of if they were damaged.*

The ***frontal*** lobe is at the front of the brain and is your decision making centre. It allows you to solve problems and make plans. This region is also important for the production of spoken language. Someone with damage to Broca's area in the frontal lobe will not be able to speak normally.
The ***parietal*** lobe is at the top of the brain. It receives touch information coming from your entire body. It also allows you to make movements in response to anything in your environment including the perception of those events in space.
The ***temporal*** lobe is at the side of the brain. It processes your memory, hearing, emotion, and language. This region is also important for language comprehension. Someone with damage to the Wernicke's area in the temporal lobe will not be able to understand language.
The ***occipital*** lobe is at the back of the brain. It takes care of your vision. Even if your eyes are perfectly normal, damage to the occipital lobe can result in blindness. Hence, we don't see with merely our eyes – we see with our brains!
The ***cerebellum*** is Latin for "little brain." This area is under the occipital lobe. It is responsible for coordinating your body movements.



3) Can we live without our lobes? (~ 5 minutes)

- → *After having gone over the aspects of the brain and what they are responsible for, you can now get the children to apply what they have learned.*
- → *Talk about the importance of the lobes using examples illustrating loss of function cases.*
- → *Promote question and answer.*

We may be able to live without ice cream, but without a lobe, life just would not be the same! If your occipital lobe is damaged, you could be blind even though your eyes are in perfect condition! The brain is where our perception of the world around us comes together!

<u>Sample Questions:</u> (think of some of your own too! ☺)
1) How would a person with injury to their cerebellum act when they are trying to swing a baseball bat?
→ *A person with cerebellar damage would not be able to coordinate their movements normally. Thus, children may be correct in answering the above question with any answers of the sort (i.e. will miss the ball, will not be able to swing…)*
2) Robert fell off his bike and wasn't wearing his helmet. After he came home from the hospital his friends noticed that he didn't like playing videogames or soccer with them anymore and he laughed at different jokes. What lobe did he damage?
→ ***Frontal lobe*** *(since this lobe is responsible for higher functions like our personality)*
3) Jane was skateboarding with some friends when she fell – after the accident she only ate food from one side of the plate and walked around with one arm in her jacket. What lobe did she damage?

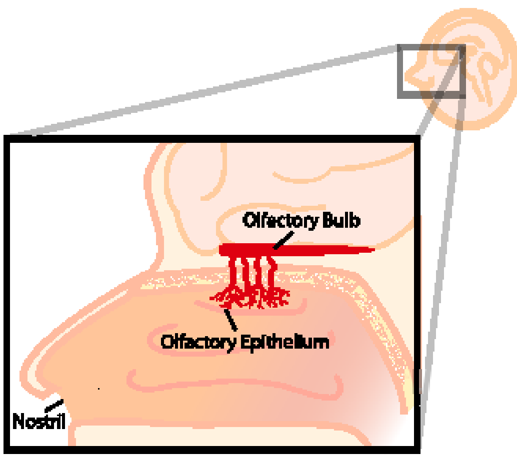
→ ***Parietal lobe***

SMELL & TASTE

[Background Information]

Smell and taste are grouped together as the chemical senses. Molecules in the air or in our mouths dissolve in watery mucous and bind to special receptors on cells that can respond to this binding interaction by sending a signal into the brain. Both smell and taste have special areas in the brain, which allow us to perceive what it is that we are smelling or tasting. This information can also remind us of things we associate with certain tastes and smells. The sense of smell has particularly close connections to emotional areas of the brain, so some smells can provoke powerful reactions or memories, maybe even before we can identify the smell.

SMELL



Smell (**olfaction**) receptors are located high inside our nasal cavities, in a small area called the **olfactory epithelium**. Molecules dissolve in the nasal mucus and stimulate receptors. The activated receptors send signals to the **olfactory bulbs**, paired structures in the brain lying just above the nasal cavities. In order to get to the brain, the receptors must send the signal through a special area of the skull called the cribriform plate, which has many tiny holes for cell extensions called axons to pass through.

Olfactory areas of the brain communicate closely with primitive areas in the brain, such as the components of the **limbic system**, a collection of brain structures that are involved in producing emotions. There are also close links to areas of the brain responsible for memory. This helps to explain why smells are capable of provoking detailed personal memories.

Humans can distinguish about 10,000 different smells. Olfaction cells express only one type of receptor, and a molecule that we smell will activate a unique set of these receptors, allowing us to identify it. There is a great deal of variability in how good our sense of smell is. Males and females perform differently, and there seems to be a decline with age.

Anosmia is the inability to smell. It can be caused by head injuries, and some diseases like Parkinson's disease. People with **anosmia** demonstrate how important our sense of smell is. They can experience depression and loss of appetite. They are also missing an important warning system; people without a sense of smell are unable to smell smoke and are also more likely to get food poisoning, as they cannot smell rotten food.

The students are asked to do an activity that demonstrates the property of **adaptation.** Our senses will adapt to a stimulus that is constantly present, and this effect is most pronounced in the sense of smell. You have probably experienced this phenomenon if you have ever painted a room in your house. After you have been in a freshly painted room for a while, you do not notice the smell. However, someone coming in from outside may come in and ask you how you can stand the smell. They can smell the paint, as it is a new stimulus, they are not adapted.

Animals use their sense of smell for many more things then humans need to, and so many animals have an incredible sense of smell. Some functions of the sense of smell are finding food, finding mates, finding others of the same species, and avoiding enemies and predators. Dogs are an example of an animal with many more olfactory receptors than humans. Insects also have a very good sense of smell. Most birds, however, have a poorly developed sense of smell.

[Smell Lesson Guideline]

1) Introduction (~10 minutes)

→ *Teaching will take place in a large group session. Children should be seated in small groups or 5-6 for the activities.*
→ *Get the students to appreciate where their olfactory receptors are located, and that they send a signal to the brain so that we can recognize what we are smelling.*
→ *The sense of smell allows us to detect chemicals in the air. Another name for the sense of smell is* ***olfaction.***

2) Smell Pathway "STEPS TO THE BRAIN": (~5 minutes)

→ *Go through the pathways with the kids. Allow them time to draw in the path into their activity booklets.*

STEPS TO THE BRAIN:
A) CHEMICALS/MOLECULES: **odorants**
B) WHERE THE MOLECULES ARE RECEIVED: **olfactory epithelium** (mucuous membrane)
C) WHERE IN THE BRAIN IT IS PERCEIVED: **olfactory bulb/temporal** lobe

Chemicals are breathed in through our nose, and bind to special receptors. These receptors are found high up inside the nose in an area called the **olfactory epithelium**.
Information about which receptors have been activated is then sent to the **olfactory bulb,** and then up higher into the brain. We can then become aware of what it is we smell in the world around us.

3) Olfactory Adaptation (~5 minutes)

→ *We have selected a strong-smelling substance for this activity. Adaptation works well with aversive odours, but we don't want to make any children sick.*
→ *Materials: several oranges, or air-freshener - enough to make a strong smell in the room.*

Ask the children to rate the strength of the smell using a scale of 1 to 10 in the space provided in their booklets. Ask the children what they think of the smell, they should have varying opinions as to how pleasant or unpleasant it is.
OPTIONAL: Ask the children if this smell provokes any memories for them. Explain that the olfactory bulbs communicate with the parts of the brain that are responsible for our emotions and memory.

4) Can a smell change? (~5 minutes)

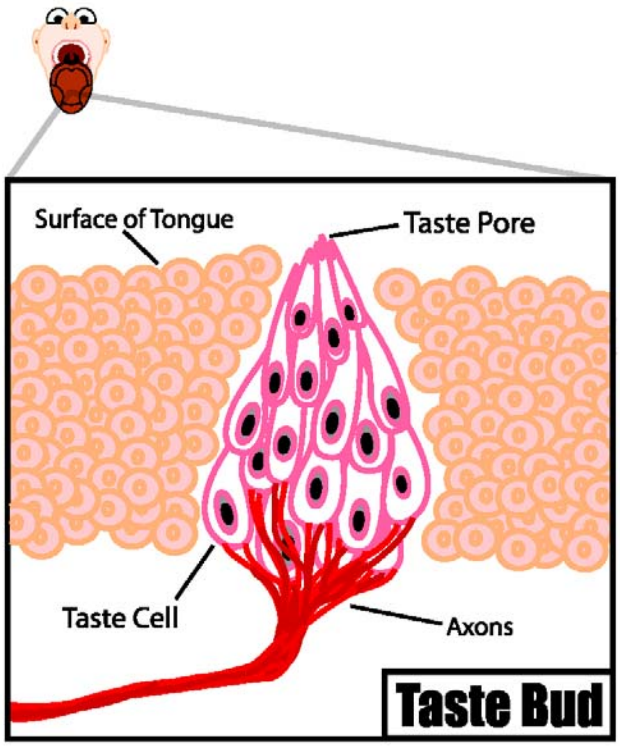
→ *Ask the children some questions about smell. Teach them what ANOSMIA is, and why it could be potentially dangerous. Promote Q & A. How can we avoid losing our sense of smell? (Waft chemicals…)*

The children are asked to think about what is would be like to lose their sense of smell. Ask them for situations where it could be dangerous, for example in a house fire or near a gas leak. (ThinkFirst!!!)
Ask about which animals have very good senses of smell. They will probably mention dogs and animals that hunt. You can also mention that insects also have very good senses of smell, as need to locate food and others of their species over long distances.

5) Adaptation? (~2 minutes)

The children should rate the strength of the orange smell/air-freshener again. If it has not decreased, they can check again at the end of the taste section. Have the children understand that they will notice a smell less if it is constantly present, and that this phenomenon is called **adaptation**.
If students do not notice a decline in the intensity of the smell, ask them again how strong the odor is at the end of the section on taste.
Ask them if they have ever noticed their sense of smell adapting, for example has anyone had a room in their house painted lately? Ask them why adaptation is important and useful?

TASTE



Taste cell receptors are clustered into **taste buds**. We actually have taste buds not only in our mouths, but on the palate (roof of the mouth) and epiglottis and upper esophagus.

At the top of each taste bud is an opening called a **taste pore**, where the taste bud comes into contact with the food molecules.
4 basic tastes are recognized: **sweet, salty, sour and bitter**. There is a lot of support for a fifth basic taste: monosodium glutamate (MSG) or **umami**. Signals from taste receptors are then sent to the brain to be interpreted

The activity for this section allows the children to explore the taste buds on their tongues. Although you can taste each of the 4 tastes on each part of your tongue, there are places where receptors for each type are more concentrated. For example, sweet is best tasted at the tip of the tongue. The last page of this manual contains a map of the distributions of taste buds for each category.

The children are asked to think about the relationship between taste and smell. In fact, much of the information about what we eat comes from the sense of smell. What we refer to as the taste of a food is actually the **flavour**. Flavour consists of the input from our taste buds, olfactory information from food molecules that make their way up into the nasal cavity, sensory information telling us what the food feels like in our mouth, and temperature. Some nerves in the mouth can even be stimulated by pungent or spicy food.

Both taste receptors and smell receptors can proliferate throughout our lives, something that cells in our brains generally cannot do. Since these receptors are found in areas that have very close contact to the outside, and come in contact with fingers, hot liquids and assorted foods, it is a good thing that damaged cells can be replaced.

[Taste Lesson Guideline]

1) Introduction (~5 minutes)

→ *Introduce how smell and taste are related.*
→ *Have them understand the concept that information from your taste cells is only a small part of what a food tastes like-its **flavour**. Smell is a major component of flavour.*
→ *Introduce the concept of **taste bud**.*

When you have a cold, your food just doesn't taste as good. Why is that?
Smell and taste work together to bring out the real "flavour" of our favourite foods! Both smell and taste are our **CHEMICAL** senses.

Taste bud = a group of taste cells grouped together. Students can examine each other's tongue. Note that what they are actually seeing are the bumps found associated with taste buds, called **papillae**.

2) Steps to the Brain (~5 minutes)

→ *Go through the pathways with the kids. Allow them time to draw in the path into their activity booklets.*

STEPS TO THE BRAIN:

1) CHEMICALS/MOLECULES: **tastants/molecules**

2) WHERE THE MOLECULES ARE RECEIVED**: taste buds/papillae**

3) WHERE IN THE BRAIN IT IS PERCEIVED: **frontal lobe,(also: insular cortex, amygdala (inner/emotional/memory brain regions basically))**

3) Taste bud mapping (~15 minutes)

→ *Materials needed: one cup of salty water per group of 4-6 students + a large supply of Q-tips (for dipping)*

→ *Present the answers to the tongue map using the **tongue acetate** provided (pre-label the answers)*

Children should take out the tongue map in their booklets to determine which areas of the tongue can "taste" the best. Instruct them to dip their tasting stick in the solution and then touch the stick to different areas of their tongue: the tip, the sides and the back (but not too far back!). Remember to take a new stick each time they dip for more solution!

Solution to the solution: Tastes are more intense where there is a greater concentration of taste receptors. The tip of the tongue has far more receptors than the middle of the tongue. The sides and the back have more receptors than the middle, but fewer than the tip. Therefore, the tip should be the "tastiest" region, followed by the sides, back and finally, the middle of the tongue.

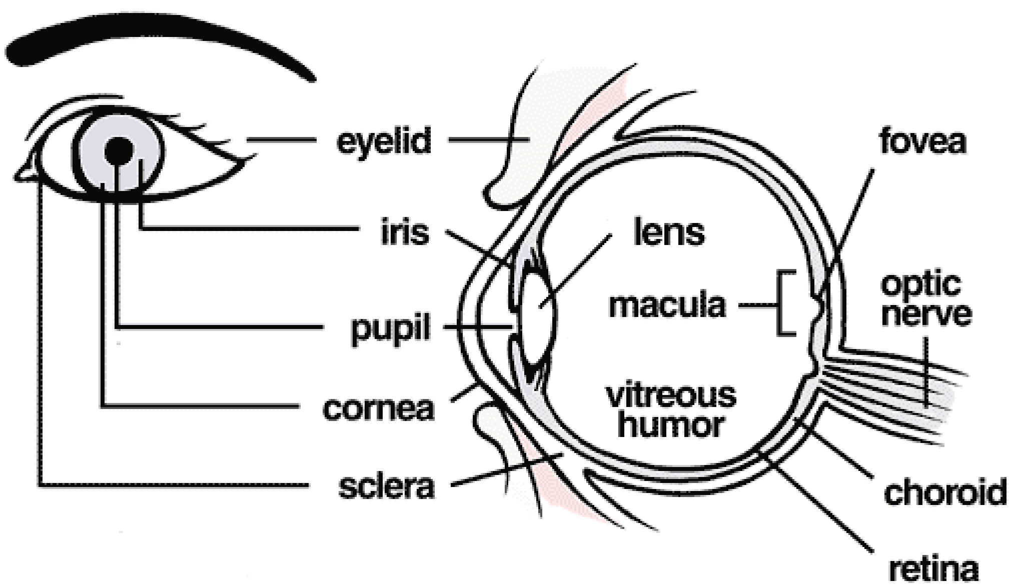
Use the tongue map acetate to mark out the regions with more and less taste receptors. Ask the children if they have ever burnt their tongues, or had sore tongues after eating too much sour candy. The pain comes from damaged taste buds, but have the kids understand that injuries like these are not permanent as new taste cell receptors are produced all the time. How is this different from other types of nerve cells we've talked about?

VISION

[Background Information]

Vision is one of the most important senses that humans use to interpret the world around us. What we "see" is LIGHT. Light includes electromagnetic radiation with wavelengths between 380 to 760 nanometres, which forms the only visible portion of the electromagnetic spectrum.

The human eye is approximately 2.5cm in length and weighs about 7 grams. Six bands of muscles are attached to the sides of the eyeball to control its movement. The EYELID provides protection for the surface of the eye. TEARS are shed to clean the eye's surface. The outer surface of the eye, the CORNEA acts like a permanent filter for the eye. The IRIS and PUPIL, automatically adjust the eye to let the right amount of light into the eye. The LENS of the eye focuses the picture automatically.



www.mvrf.org - illustration based upon information from National Eye Institute / National Institutes of Health

When light enters the eye through the lens, it is captured onto the back of the eye known as the RETINA. The retina contains two kinds of cells (photoreceptors) that sense light, the RODS and CONES. The rods are responsible for dark vision and detection of movement, while the cones are used for detection of colour and fine detail. This information leaves the eye through OPTIC NERVES and travels to the brain. The optic nerve exits the eye at the BLIND SPOT. The blind spot does not contain any photoreceptors, therefore cannot see light. The optic nerves cross the midline of the brain at the OPTIC CHIASM before reaching the OCCIPITAL LOBE on the opposite side of the brain.

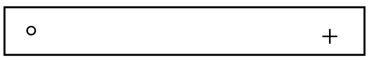
[Lesson Plan]

1. Anatomy of the Eye (~10 minutes)

- Quickly explain the function and location of the following parts of the eye.
  - i. Eyelid
  - ii. Lens
  - iii. Pupil
  - iv. Iris (= colour of eye)
  - v. Retina (rods, cones)

- The Visual Pathway
  - Explain the visual pathway outlined as follows:
    - i. Light enters eye through lens → Retina → Optic nerve (Blind Spot) → Optic Chiasm → Occipital Lobe (Visual Cortex)
  - Guide the kids to connect the dots on the diagram on the first page, which outlines the visual pathway.

- Blind Spot Activity



  - The strips of paper (shown in diagram on left) needed for this activity is prepared in the Brain Box
  - Instructions for the kids:
    - i. Hold the strip of paper with your left hand out at arms' length. Orient the + on the right and ° on the left.
    - ii. Cover your right eye with your right hand.
    - iii. Focus your left eye on the + on the right.
    - iv. Slowly move the strip towards you until the ° sign disappears. (Keep focusing your left eye on the + sign)
  - The location at which the ° sign disappears is the blind spot.

- Fill out the "Steps to the Brain" with the kids in their activity booklet.
  - *Fill this out with the kids only if time permits. If not, please tell them to fill this out on their own at home.*

STEPS TO THE BRAIN:

A) WE SEE: L IGHT

B) WHERE THE MOLECULES ARE RECEIVED: R ETINA

- On the retina, there are 2 types of cells (photoreceptors)
  - i. R ODS are for dark vision and detection of movement.
  - ii. C ONES are for colour vision and detection of fine detail.
- Information from our retina exits the eye at the B LIND S POT

C) WHERE IN THE BRAIN IT IS PERCEIVED: O CCIPITAL L OBE

2. 3D Perception (~ 10 minutes)

Instructions for the Demonstration

- *i. Ask for 2 volunteers*
- *ii. Place a garbage can at one end of the room.*
- *iii. Crumple up a piece of scrap paper.*
- *iv. Ask the 1st volunteer to stand at the other end of the room.*
  (Note: He/She must still have full view of the garbage can)
- *v. Ask the 2nd volunteer to hold the crumpled piece of paper with his/her arms out and stand 5 steps away from the garbage can.*
- *vi. Ask the 1st volunteer to cover one eye*
- *vii. Ask the 1st volunteer to give instructions to the 2nd volunteer so that he/she can drop the crumpled piece of paper straight down into the garbage can.*
- *viii. **If time permits**, repeat steps iv – vii **without** covering any eye.*

- Explanation for the Demonstration
  - The 1st volunteer should find it more difficult to instruct the 2nd volunteer to throw out the garbage when his/her eye is covered.
  - This is because when one eye is covered, stereovision (3D perception) is lost.
  - 2 eyes = 3D Perception!!
  - Each eye captures its own view and the two separate images are sent on to the brain for processing. When the two images arrive simultaneously in the back of the brain, they are united into one picture. The mind combines the two images by matching up the similarities and adding in the small differences. The small differences between the two images add up to a big difference in the final picture! The combined image is more than the sum of its parts. It is a three-dimensional stereo picture.
  - Stereovision--or stereoscopic vision --probably evolved as a means of survival. With stereo vision, we can see **WHERE** objects are in relation to our own bodies with much greater precision

- Describe the importance of having stereo vision

  - Examples of occupations that depend heavily on stereoscopic vision include: baseball player, waitress, driver, architect, surgeon and dentist
  - Examples of general actions that depend heavily on stereo vision include: throwing, catching or hitting a ball; pouring into a container; Reaching out to shake someone's hand and driving and parking a car

3. Optical Illusions (~ 10 minutes)

a. Let's Investigate: Seeing Colours!

Instructions for Colour Afterimage Activity

i. *Place the overhead of colour afterimages onto the projector*
ii. *Tell the kids to stare at the image for 1 minute. (You are keeping time)*
iii. *Quickly remove the overhead after 1 minute*
iv. *Ask the kids what they see*

- Explanation of Colour Afterimage Activity
  - Each colour has an opposite colour. Red is the opposite of green, blue is the opposite of yellow and white is the opposite of black. Opposite colours can be seen through afterimages.
  - This is known as the *Opponent Processing Theory of Colour Vision*
  - Imagine there are three tubes, each containing two set of paint. When you are using one tube, you can only use ONE of the two colours it contains. Never the two colours together. (No such thing as yellowish-blue, greenish-red or blackish-white!). Since these colours cannot be found together, they are opposite colours. If a colour wheel is available, it would be useful in explaining this concept.
  - Afterimages are seen because neurons become adapted to the colour you are staring at. The neuron gets tired, removing the inhibition on the opposite colour once the stimulus is removed.

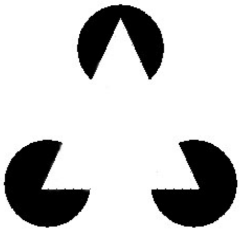
- Direct students' attention to the additional similar illusions and summary of explanation in the student manual on page 11.

- If time permits, describe achromatopsia (Colour Blindness)
  - Some people are not able to see color because they are missing a cone type(s), have some type of abnormality in the cone or have some abnormality in the colour perception area (ie. V4) of the occipital lobe.
  - Colour blind tests have been made to check for color blindness.

b. **Let's Investigate: Your eyes like to see…**

- <u>The Illusory Contour Illusion</u>
  i. Place the overhead on the projector

  ii. Ask the kids the following questions:



Q: *What does this look like?*
A: a triangle on top of three circles

Q: *What makes a triangle?*
A: 3 lines of equal length at 60 degree angles to each other

Q: Is the triangle really there?
A: No

iii. Explanation

- Our brains make sense of what we see by <u>FILLING IN</u> the missing pieces in what we see.

- This illusion teaches us that vision is constructive. What we really see is three circles, each missing a chunk. However, they are arranged in such a way that it looks like the missing parts in each circle make a vertex of a triangle. Our visual system completes this picture by constructing lines between the circles that would complete the triangle. These lines don't really exist, but our brain puts them there so that the figure makes sense.

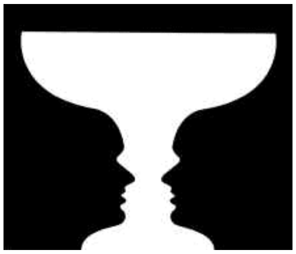
- A lot of the objects that we see are partially occluded by other objects. Since we usually interact with objects in our world, the brain constructs the missing parts in our mind. That way, we know that the entire object is there and we know what we can do with it. For example, if you see only the stalk of an apple hidden behind leaves, your brain will construct the rest of the apple in your mind. You then know that if you reach behind the leaves, you will find an apple that you can eat. If your brain didn't construct the missing parts, you would walk away thinking there was only a stalk there and be hungry.

iv. Direct students' attention to the additional similar illusions and summary of explanation in the student manual on page 12.

c. Let's Investigate: Practice Makes Perfect

- Reversible Figures Illusion (Vase, faces)
  i. Place the overhead on the projector

  ii. Ask the kids the following questions:



Q: *If you focus on just the black part, what do you see?*
A: two faces looking at each other

Q: *Now look at the white part only, what do you see?*
A: a vase

iii. Explanation

- We can see two different images because we can only pay attention to ONE IMAGE at a time. For example, if you look at a painting on a white wall, you would focus on the PAINTING, and pay little attention to the wall.

- When we are looking at a scene, we have to parse (divide) the objects into figure and ground. The figure is what we pay attention to and the ground is the background that we know is there but don't really look at. This parsing is important because we cannot focus on everything in the scene at once. We have to divide our energy and our visual system is designed to quickly figure out what is the figure and what is the ground. Parsing makes us more efficient.

- Most scenes we look at have only a few objects in them that really interest us. So, devoting our attention to them allows us to see more detail in that object rather than waste it on a mundane background. For example, if you look at a painting on a white wall, you look at the wall only for a second and then focus on the painting. You could look at the wall for another 10 minutes and it would be very uninteresting. Instead, it would make more sense to spend your time admiring the painting.

iv. Direct students' attention to the additional similar illusions and summary of explanation in the student manual on page 13.

HEARING

[Background Information]

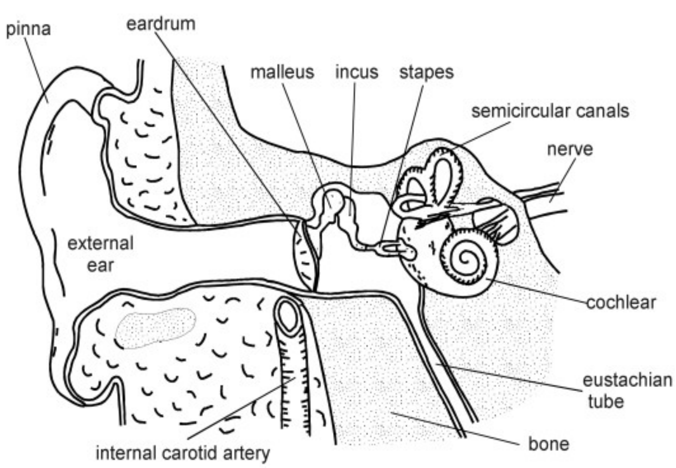
SOUND BASICS

To understand how your ears hear sound, you first need to understand just what sound is. An object produces sound when it vibrates in matter. This could be a solid, such as earth; a liquid, such as water; or a gas, such as air. Most of the time, we hear sounds traveling through the air in our atmosphere.

When something vibrates in the atmosphere, it moves the air particles around it. Those air particles in turn move the air particles around them, carrying the pulse of the vibration through the air. A vibrating object sends a wave of pressure fluctuation through the atmosphere. We hear different sounds from different vibrating objects because of variations in the sound wave FREQUENCY. A higher wave frequency simply means that the air pressure fluctuation switches back and forth more quickly. We hear this as a higher PITCH. When there are fewer fluctuations in a period of time, the pitch is lower. The level of air pressure in each fluctuation, the wave's AMPLITUDE, determines how loud the sound is.

THE MECHANICS OF HEARING

The ear is divided into three parts: outer ear, middle ear and inner ear.

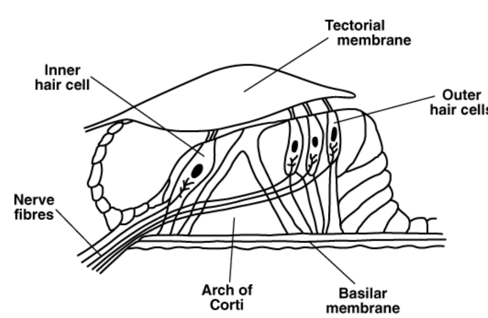


CROSS SECTION OF THE EAR

The function of the OUTER EAR (pinna) is to collect sound waves and funnel them through the ear canal to the eardrum (tympanic membrane). SOUND WAVES cause the tympanic membrane (eardrum) to vibrate. Humans can hear sounds waves with frequencies between 20 and 20,000 Hz. The outer two-thirds of the pinna is lined with cartilage, and contains sebaceous and wax glands. The wax prevents foreign objects from traveling down the canal. Old wax is expelled as new wax is produced.

The MIDDLE EAR is an air-filled space containing the three smallest bones in the human body. These bones, called OSSICLES (malleus, incus, stapes), amplify and transmit the sound vibrations across a tiny membrane (oval window) into the cochlea.

When sound waves reach the INNER EAR, they enter the cochlea. The COCHLEA is a snail-shaped, fluid-filled structure in the inner ear. Inside the cochlea is another structure called the organ of Corti. 25,000 tiny nerve endings, also known as HAIR CELLS, are located on the basilar membrane of the organ of corti. The cilia (the hair) of the hair cells make contact with another membrane called the tectorial membrane. When the hair cells are excited by vibration, electrical nerve impulses are generated in the auditory nerve. These impulses are then sent to the brain, where these signals are interpreted as sound information.



1. **The Auditory Pathway (~ 5 minutes)**
   a. Explain the auditory pathway as follows:
      Outer Ear (Pinna) → Outer Ear (Eardrum) → Middle Ear (Name the 3 Ossicles: malleus, incus, stapes) → Inner Ear (Cochlea) → Inner Ear (Hair Cells) → Auditory Nerve → Temporal Lobe

   b. If time permits, fill out the "Steps to the Brain" with the kids in their activity booklet.

STEPS TO THE BRAIN:

A) We hear S OUND W AVES

B) Where sound waves are perceived: C OCHLEA
   Hair cells in the cochlea transmit auditory information to the brain

C) Where in the brain it is perceived: T EMPORAL L OBE

2. Sound Localization: "Hearing in the Middle" Demonstration (~ 8 minutes)

Instructions for the Demonstration

- i. *Ask for 6 volunteers*
- ii. *Blindfold one of the volunteers and ask him/her to sit on a chair in the middle of the room. (Note: Make sure the blindfold does not cover the ears)*
- iii. *Inform the rest of the 5 volunteers that when you signal to them, they have to make a sound (ie. clapping)*
- iv. *Ask each of these volunteers to walk 5 steps away from the seated volunteer in different directions.*
- v. *Make sure the class is quiet during the activity*
- vi. *Tell the seated volunteer to cover one ear*
- vii. *Signal one of the other volunteers to make a sound*
- viii. *Ask the seated volunteer to point towards the direction of the sound*
- ix. *Repeat this several times*
- x. *Ask the seated volunteer to NOT cover his/her ear*
- xi. *Repeat steps vii – ix*

- Explanation for "Hearing in the Middle" Demonstration
  - The seated volunteer should be more accurate in identifying the direction of the sound when they can use both ears.
  - For most people, it will be easier to judge distance using two ears. Our brains use the loudness of sounds and the differences in time for sounds to reach each ear to make accurate determinations of sound locations.

3. Highlight the importance of protecting your hearing (~ 2 minutes)

- Exposing your ears to loud noises can lead to sensorineural hearing loss by destroying the hair cells of the inner ear.
- This can be prevented by avoiding exposure to loud noises, by avoiding noisy situations or using earplugs/ear covers. High noise levels damage or kill hair cells.
- Tumors, objects in the ear canal, or repeated ear infections that damage the eardrum can cause conductive hearing losses.

TOUCH

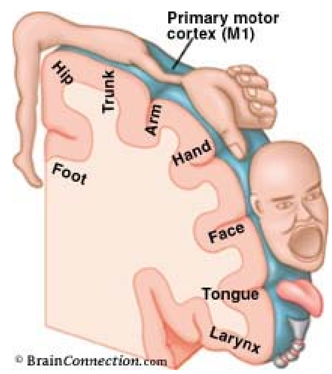
[Background Information]

The somatosensory system is a part of the nervous system that processes information related to one of our five senses: the sense of touch.

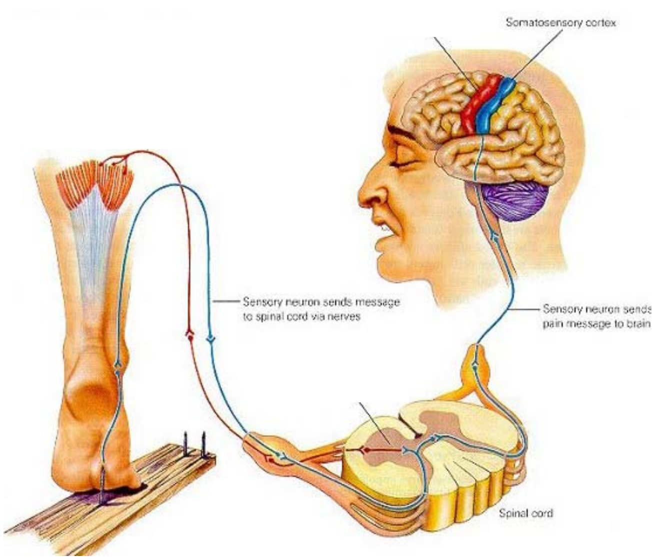
Receptor Type	Stimulus
Pain	▪ Tissue damage ▪ physiological ▪ inflammatory ▪ neuropathic
Temperature	▪ Heat (30°C – over 45°C) ▪ cold (10°C to 38°C)
Pressure	▪ Discrimination between 2 points (fine touch)
Vibration	▪ Vibrations on the skin
Proprioception	▪ Determines our position in space

The sense of touch can be divided into 5 submodalities (please refer to table) according to the different SENSORY RECEPTORS that are needed to detect the different types of stimuli. The properties of the receptors and the neurons allow us to interpret sensation. Every stimulus, whether it is chemical, thermal or mechanical, is changed to an electrical signal that the brain can understand. The special part of the brain that receives this sensory input is called the SOMATOSENSORY CORTEX on the post-central gyrus.

The somatosensory cortex is somatotopically organized and can be depicted by the HOMUNCULUS (refer to figure below). The unusual body proportions of the homunculus reflect the relative sizes of sensory receiving areas from different body parts. A larger area of representation in the brain equates to greater sensitivity of the body part relative to others. This is due to the fact that different parts of the body have different densities of receptors. Very sensitive areas of the skin, like your fingertips, have closely packed neurons with small receptive fields.



The right hemisphere controls the left side of the body and the left hemisphere controls the right side of the body. (CONTRALATERAL ORGANIZATION)



TWO-POINT THRESHOLD refers to the minimal distance by which two touch stimuli must be separated in order to be perceived as separate. This distance is the smallest where touch receptors are the most abundant (ex. The fingers).

A REFLEX is a reaction that your body has which you cannot consciously control. A reflex works in a very simple way: it starts with an outside stimulus that the sensory neurons detect. They produce an electrical impulse that travels to motor neurons. These motor neurons then transfer this information to the muscles and cause them to contract.

1. The Touch Pathway (~ 5 minutes)

a. Explain the touch pathway as follows using the **body outline acetate** provided:
   5 Touch Receptors on Skin (identify them) → Spinal Cord → Somatosensory Cortex (Parietal Lobe)

b. If time permits, fill out the "Steps to the Brain" with the kids in their activity booklet.

STEPS TO THE BRAIN:

A) WE FEEL:
   P AIN
   P RESSURE
   T EMPERATURE
   V IBRATION
   Proprioception

B) WHERE ARE YOUR TOUCH RECEPTORS? S KIN

C) WHERE IN THE BRAIN IT IS
   a. PERCEIVED: P ARIETAL L OBE

2. Pain "Pinching" Activity (~ 5 minutes)

Instructions for Activity

i. Get students into pairs.
ii. Distribute ONE clothespin to each pair of student
iii. Have one student clip the pinky finger of another student with a clothespin.
iv. Take the clothespin off the pinky, and clip on the flappy skin on the elbow.
v. Ask the students to repeat the above steps with their partners
vi. Ask the students to vote on whether they find it more painful when clipping the finger or when clipping the elbow flap.

- Explanation for the "Pinching" activity
  - The clothespin should sting more when it was on your pinky finger, than when it was on your elbow.
  - This is because the distribution of **pain receptors** is different for different parts of the body, making these parts more or less sensitive to pain. For example, your eyes are extremely sensitive to pain -- a few hundred times more sensitive than the bottom of your feet! And as you probably found out, your elbow has next to no pain receptors. This is why you can barely feel the clothespin on your elbow.

3. Two Point Discrimination Demonstration:*** (~ 5 minutes)

Instructions for Demonstration:

i. Ask for 1 volunteer
ii. Blindfold the volunteer or ask them to close their eyes
iii. Tell them to hold up their arms with fingers spread out
iv. Use 2 toothpicks and lightly poke the finger
v. Ask the volunteer:
   Q: How many toothpicks am I using to poke you?
   A: They should say 2
vi. Use the same 2 toothpicks and lightly poke the arm/back at the same distance
vii. Ask the volunteer:
   Q: How many toothpicks am I using to poke you?
   A: They should say 1

- Explanation for the "Two Point Discrimination" activity
    - you should be able to distinguish the materials better at your fingertips than your upper arm or back. (ie. your fingers are more sensitive to touch)
    - This is because of receptor distribution -- there are simply more touch receptors that are more densely packed, at your fingertips, than at your back or arms. As well, these receptors have a smaller **receptive field** -- they respond to a smaller area of skin stimulation. And also, look at the homunculus for a minute -- notice that its hands and fingertips are much larger than its knees and forearm. This means there is more brain area devoted to sensation in the fingertips. The amount of brain for each body part is important in determining how sensitive that body part is towards touch -- the more brain it has, the more sensitive it is.
    - Briefly explain the HOMUNCULUS with respect to this activity. (Using the **homunculus acetate** provided in the box.) Show that the fingers, mouth, tongue (areas of high sensitivity → densely packed receptors) have a greater representation in the homunculus!

- ***Alternative Activity: (if the children refuse to be poked with toothpicks)
    - Using scraps of different material (paper towel, felt, cotton balls)
    - Perform the above demonstration using these materials instead of the toothpicks
    - Result: it will be easier for the student to tell what the material is with his/her fingers rather than his/her back (more receptors in fingers)

WRAP-UP

- *Re-iterate the importance of the brain and what it would be like to lose any of the senses*
- *Emphasize that the best way to protect the brain is through injury prevention (ie. Wearing their helmets while cycling, skateboarding…etc., wearing your seatbelt)*
- *Say your Good-byes to the Kids*
- *Return the Evaluation Sheets (including the teacher evaluation) and any receipts from the teacher to envelope provided, seal it, and drop it in the mail.*

A Special Message for you…

YOU ARE DONE!!!!

On behalf of the kids and ThinkFirst, THANK YOU very much for your participation in Brain Day 2008. ☺

ThinkFirst gratefully acknowledges the support of:

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