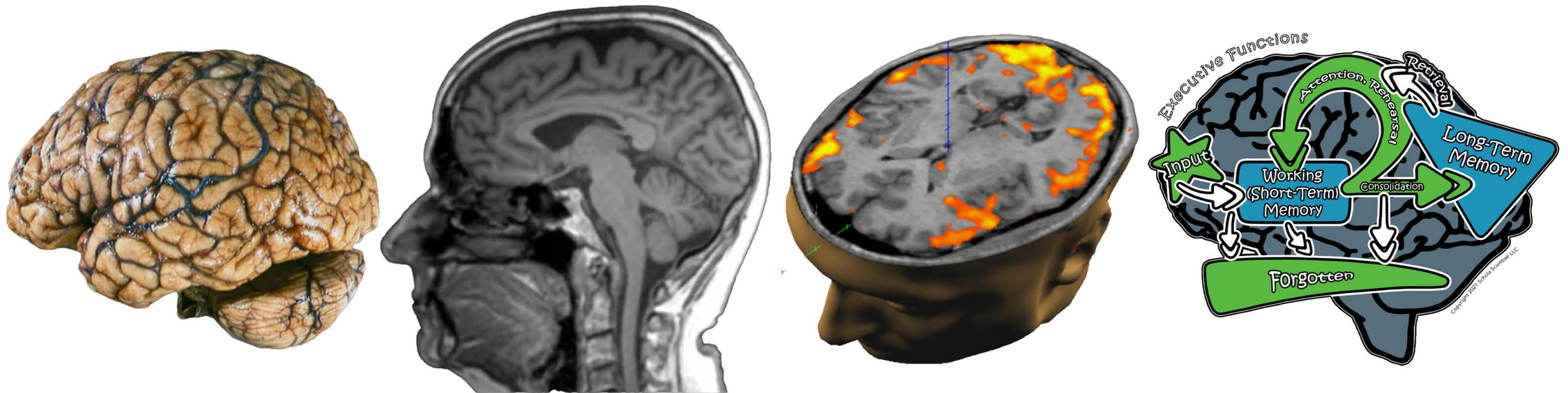




Teacher Guide

Tips for Success

- Login to your account on the **Human Cognition Student Portal**, then leave the page open so you can access the Background, Concept day slides, and other pages.

1.1 Identify your work:

You will work with a collaborative team of scientists for Phases 1 and 2. Doing so will increase the reliability of your results.

You will complete Phase 3 independently. Doing so will enable you to reflect on your personal development and process as a whole.

Your Name:

Group or lab Partners:)

1.3 Baseline Observation:

Briefly explain what you currently understand about simple information processing like reflexes. Doing so will allow you to evaluate your work over time.

Student answers will vary.

2.1 Background Research:

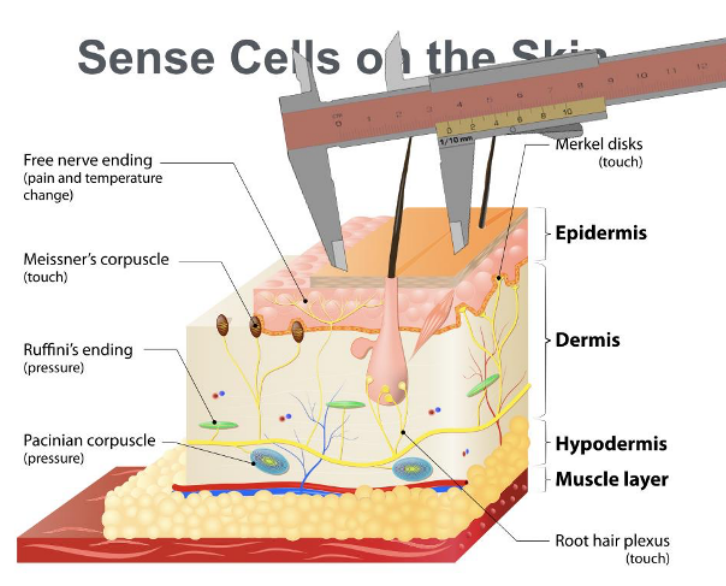
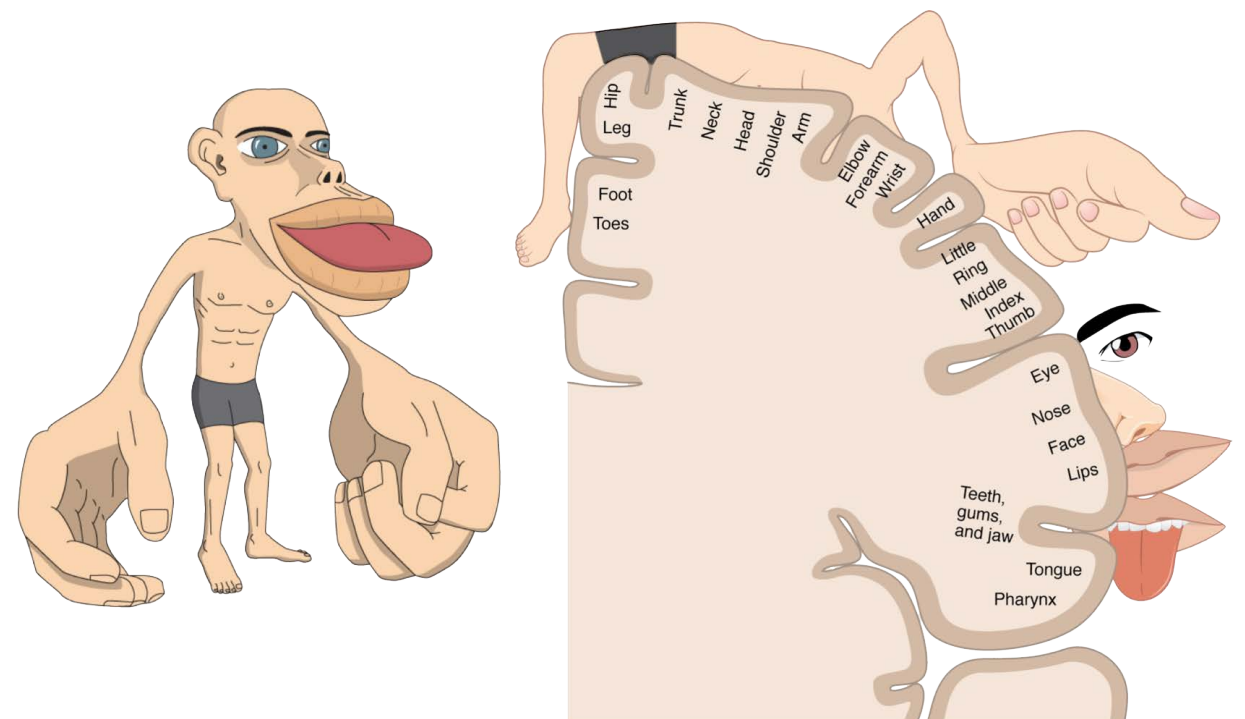
Open the *Introduction* and *Concept Slides* via the *Student Portal*. As you read through the information, think critically, asking questions and evaluating the claims - not simply accepting what you read. Take note of any information that will help you answer the *Phase 2.2* questions. After reading the research, complete the *Student Guide* through and including *Phase 2.2*, and prepare to share your thoughts during the class presentation of the information.

Sensory Homunculus

The strange-looking figure in this image is called a sensory homunculus. The word **homunculus** means little man. Scientists created this model to show how much of the brain's sensory cortex is devoted to feeling in different parts of the body.

Body parts that are very sensitive to touch, like the lips, tongue, and hands, are shown much larger than they really are. Less sensitive areas, like the back or legs, are shown much smaller. The size of each body part in the homunculus represents how many nerve endings send signals to the brain from that area.

This model helps us understand why we can feel very fine details with our fingertips but not with our backs, and why some reflex tests focus on the face or hands. It shows that the brain doesn't treat all body parts equally some areas are much more important for sensation.



Two-Point Discrimination

The density of touch receptors is different in different parts of the body. The two-point discrimination test can measure the density of touch receptors in a particular area of the body. If you were to perform the two-point discrimination test on all areas of the body, you would be able to map your own homunculus (somatosensory cortex)

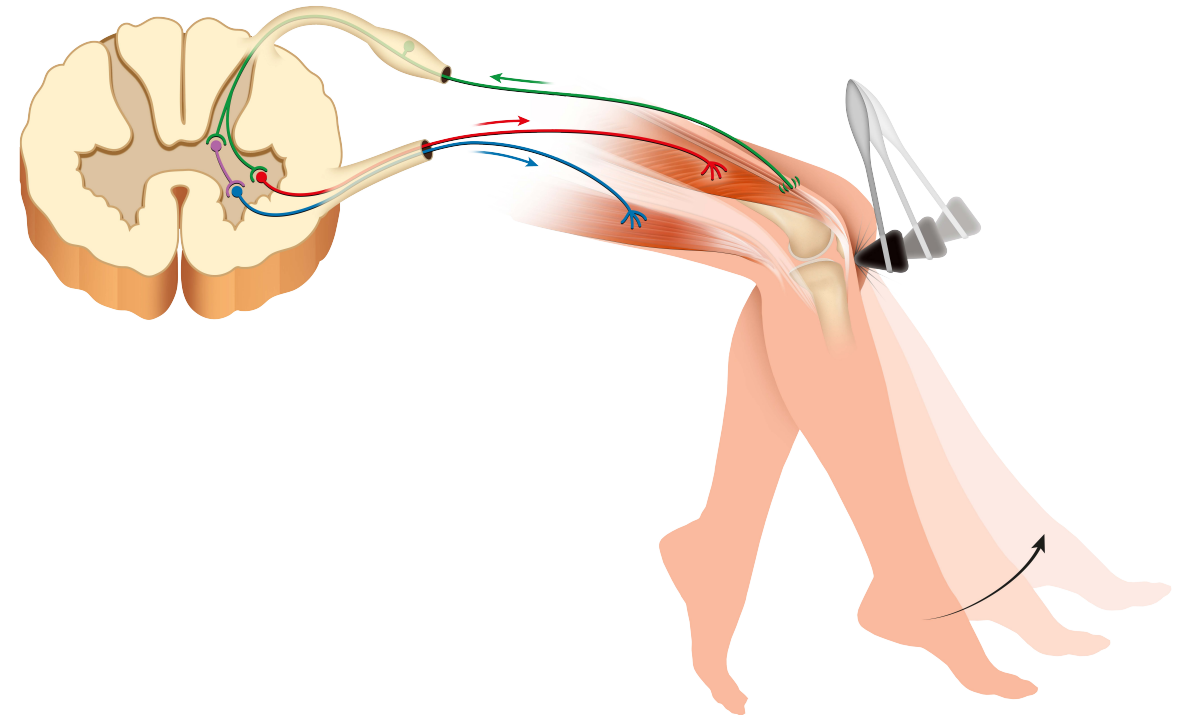
2.1 Background Research (continued):

Reflex Response (Knee Jerk Reflex)

The patellar reflex, or knee jerk reflex, is one of the simplest examples of how the nervous system works. When a doctor or teacher taps just below the kneecap with a reflex hammer, it stretches the tendon connected to the quadriceps muscle in the thigh. Special sensory neurons detect this sudden stretch and send a signal directly to the spinal cord.

Instead of traveling all the way to the brain, the spinal cord quickly processes the signal and sends a message back through motor neurons to the muscle. This makes the quadriceps contract, causing the lower leg to kick forward.

This fast and automatic response protects the body by helping muscles adjust to sudden changes in length. Reflexes like this are important for balance, posture, and safety because they happen without us having to think about them.



We can identify each of five components of the reflex arc:

Receptor: The muscle spindle in the quadriceps detects when the tendon is tapped and stretched.

Sensory Neuron: The stretch signal travels from the receptor to the spinal cord through a sensory neuron (green).

Integration center (Spinal Cord): In the spinal cord, the sensory neuron synapses directly with a motor neuron (red) - this is a monosynaptic reflex. At the same time, an interneuron (purple) sends an inhibitory signal to the neuron (blue) that normally activates the hamstrings.

Motor Neuron: The motor neuron (red) sends the return signal back to the quadriceps muscle.

Effector: The quadriceps muscle contracts, producing the lower leg kick.

Inhibitory Effect on the hamstrings: To make the movement smooth, the spinal cord also inhibits the hamstrings (blue neuron). This is called reciprocal inhibition - while the quadriceps contract, the hamstrings relax, preventing them from resisting the motion.

2.1 Background Research (continued):

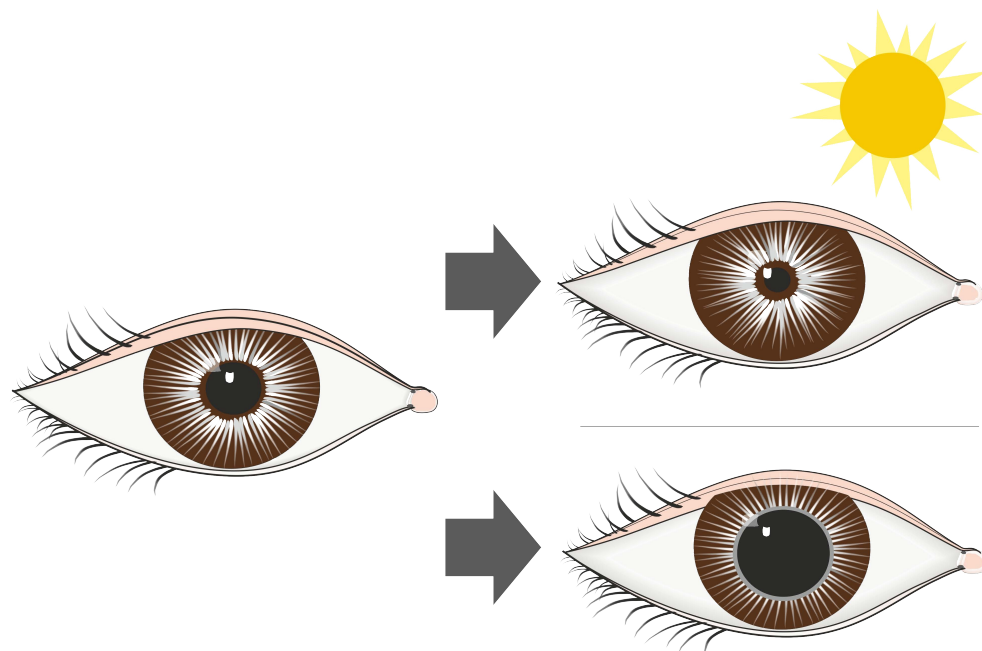
Pupillary Reflex

The pupillary reflex is an automatic response that controls the size of the pupil in the eye. The pupil works like the opening of a camera, adjusting to let in just the right amount of light.

When bright light shines into the eye, the pupil quickly becomes smaller (constricts) to protect the retina from too much light. In dim light, the pupil becomes larger (dilates) to let in more light so we can see better. This response happens very fast and without us thinking about it.

The reflex begins when light enters the eye and activates special cells in the retina. These cells send signals through nerves to the brain. The brain then sends signals back to the muscles in the iris (the colored part of the eye), causing the pupil to shrink or widen.

Doctors often test the pupillary reflex with a flashlight to check whether the nervous system is working properly. It is an important reflex because it protects our vision and helps us adjust to changing light conditions.



2.2 Response to Your Research: Answer the question(s) then list **three new facts** you learned from your research.

1.1. In your own words, explain what a reflex arc is. Give several examples and discuss the importance of each.

A reflex arc is the pathway that a nerve signal follows when the body makes an automatic response without needing to think about it. The signal usually travels from a receptor (like in the skin or eye), through sensory neurons to the spinal cord or brainstem, and then back out through motor neurons to make muscles move. Reflex arcs happen very quickly because they don't always need to involve the higher brain.

Examples and Importance:

Knee-Jerk Reflex (Patellar Reflex): When the tendon below the kneecap is tapped, the leg kicks out. This protects muscles from stretching too much and helps maintain balance and posture.

Pupillary Reflex: When bright light shines in the eyes, the pupils get smaller. This protects the retina from damage and helps us see clearly in different lighting.

Two-Point Discrimination Reflex (Skin Receptors): Using a compass or similar tool, the skin can sense whether one or two points are touching it. Fingers and lips are more sensitive than the back or legs. This helps us interact with the world safely and precisely, such as picking up objects or avoiding injury.

Overall Importance:

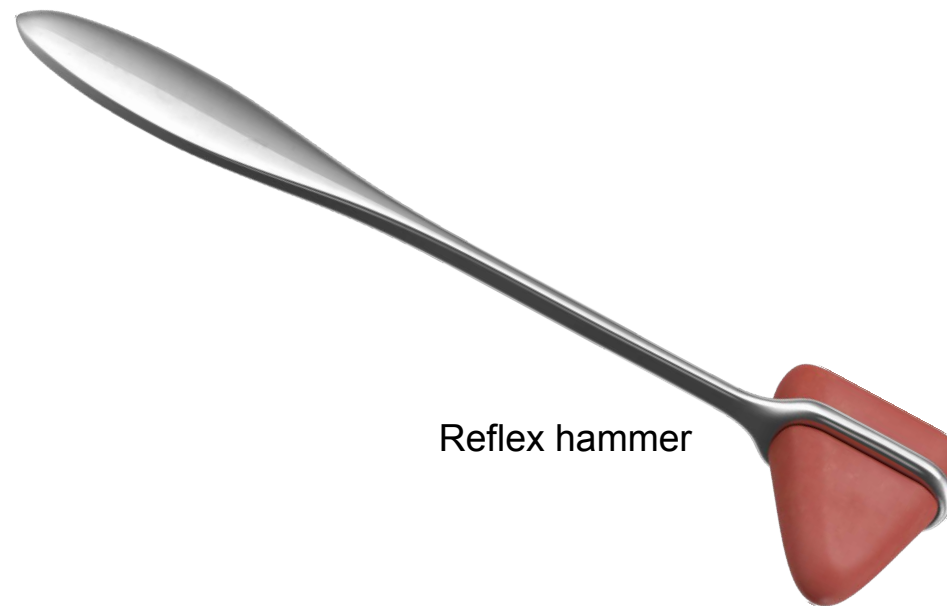
Reflex arcs are important because they keep us safe, protect our senses, and allow the body to adjust automatically to changes in the

2. List and briefly explain three new/interesting facts you have learned from your background research.

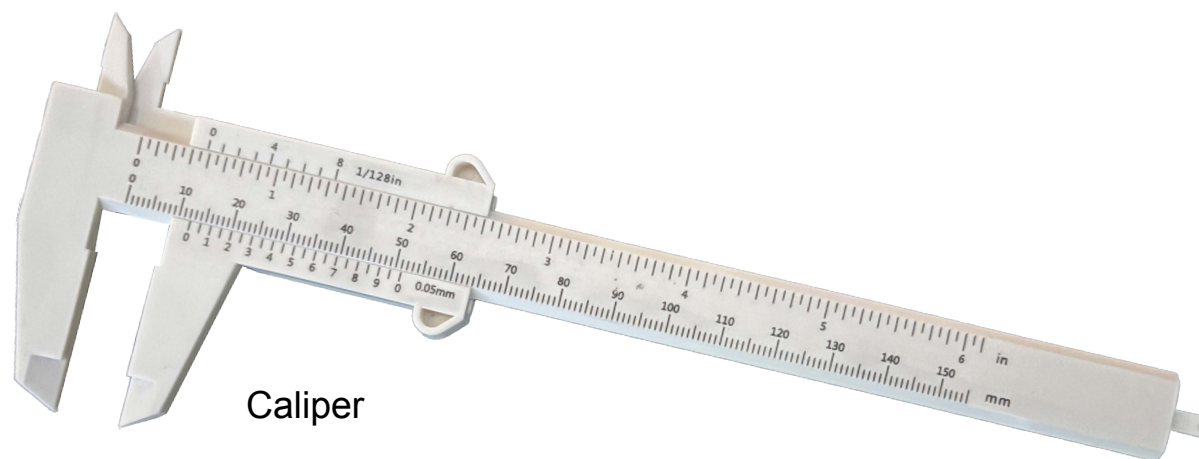
Student answers will vary.

2.3 Experiment-Materials:

- ☐ Laptop
- ☐ Caliper
- ☐ Reflex hammer
- ☐ Penlight



Reflex hammer



Caliper



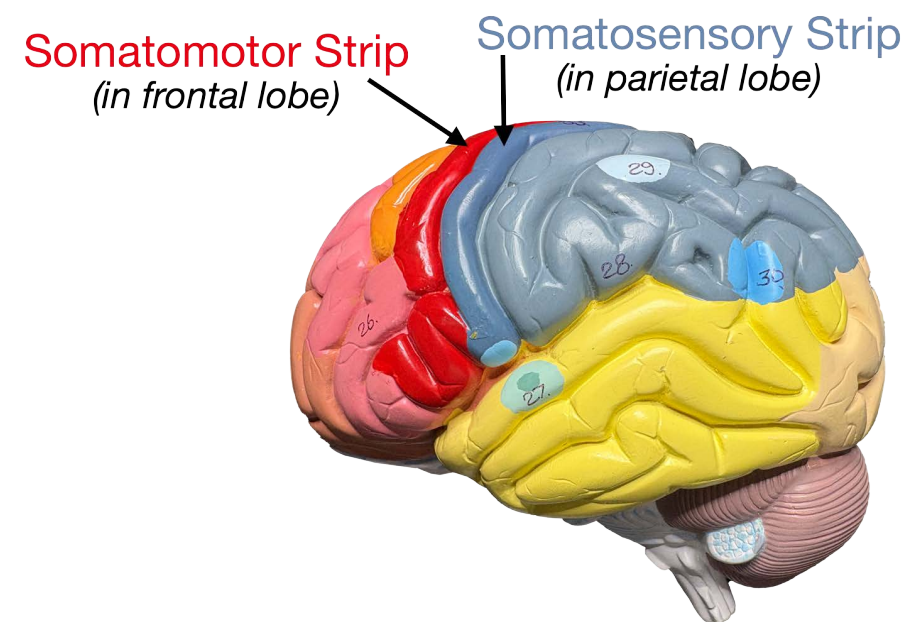
Penlight

2.4 Experiment-Protocol

Two-Point Discrimination

The density of touch receptors is different in different parts of the body. The density of touch receptors in a particular area of the body can be measured by the two-point discrimination test. If you were to perform the two-point discrimination test on all areas of the body, you would be able to map your own homunculus (somatosensory cortex)

- ☐ 1. Select a partner.
- ☐ 2. Each pair should obtain the following:
 - a. one pair of adjustable calipers
- ☐ 1. Each pair will test the following areas of the body
 - a. back of hand
 - b. finger tip
 - c. calves
 - d. lips
- ☐ 2. Find two chairs and sit down facing each other.
- ☐ 3. Place your hand on your leg with the palm facing down.
- ☐ 4. Your partner should set the calipers so the two points are approximately 10 centimeters (100 mm) apart from each other. (If the calipers will not fit on the back of your hand have your partner move them 1 or 2 centimeters closer together and note the starting distance.)
- ☐ 5. Your partner should gently touch the calipers to the back of your hand and ask whether you feel one point or two. Your eyes should be closed during this time.
- ☐ 6. Your partner should pick up the calipers, move the points 5 mm (0.5 cm) closer together and gently touch the skin of the same area of the back of the hand. He or she should again ask whether you feel one point or two.

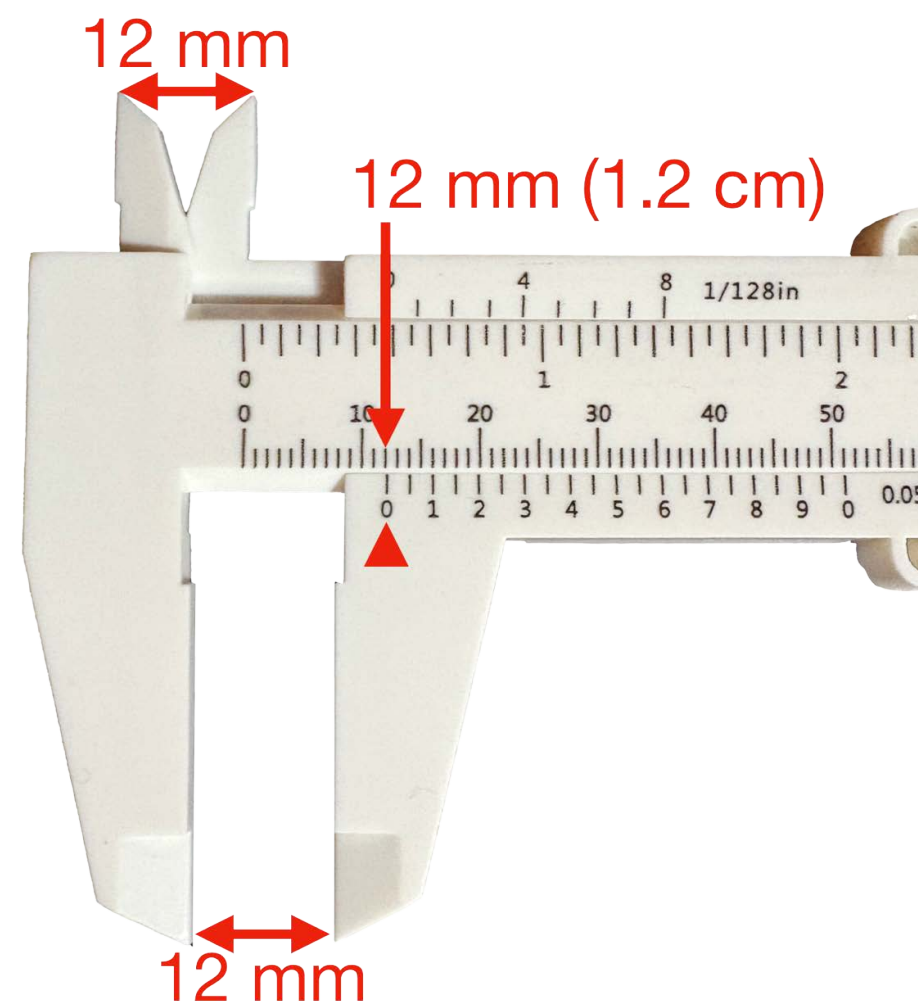


2.4 Experiment-Protocol (Continued)

- ☐ 9. Your partner should gradually move the points of the caliper 5 mm (0.5 cm) closer together until you feel only one point. When this occurs, your partner should note the distance between the points on the calipers and record the distance in **Table A** below.
- ☐ 10. Your partner should repeat the same procedure on your finger tip, calves, and lips.
- ☐ 11. Record your results in **Table A** below (be sure to include units):

Table A

	Distance Subject Feels Only One Point
Back of Hand	
Finger tip	
Calves	
Lips	



2.4 Experiment-Protocol (Continued)

Knee-Jerk Reflex (Patellar Reflex)

- ☐ 1. elect a partner.
- ☐ 2. Each pair should obtain the following
 - a. Reflex hammer (or similar rubber-tipped instrument)
 - b. Two chairs or stools (or lab bench)
- ☐ 3. The subject should sit on a chair (or lab bench) with both feet hanging freely (not touching the floor). The legs must remain relaxed.
- ☐ 4. Locate the patellar tendon just below the kneecap.
- ☐ 5. The tester should gently tap the tendon with the reflex hammer. Observe whether the lower leg kicks forward.
- ☐ 6. Repeat this test on both legs, recording the reflex strength using the following scale
 - 0 no movement
 - 1 slight movement
 - 2 normal kick
 - 3 strong kick
- ☐ 7. Next, have the subject perform the Jendrassik maneuver clasp fingers together, pull firmly outward, and grit teeth while the tester taps the tendon again. Record the reflex strength.
- ☐ 8. Compare your baseline and Jendrassik results for left and right legs. Record observations in Table B

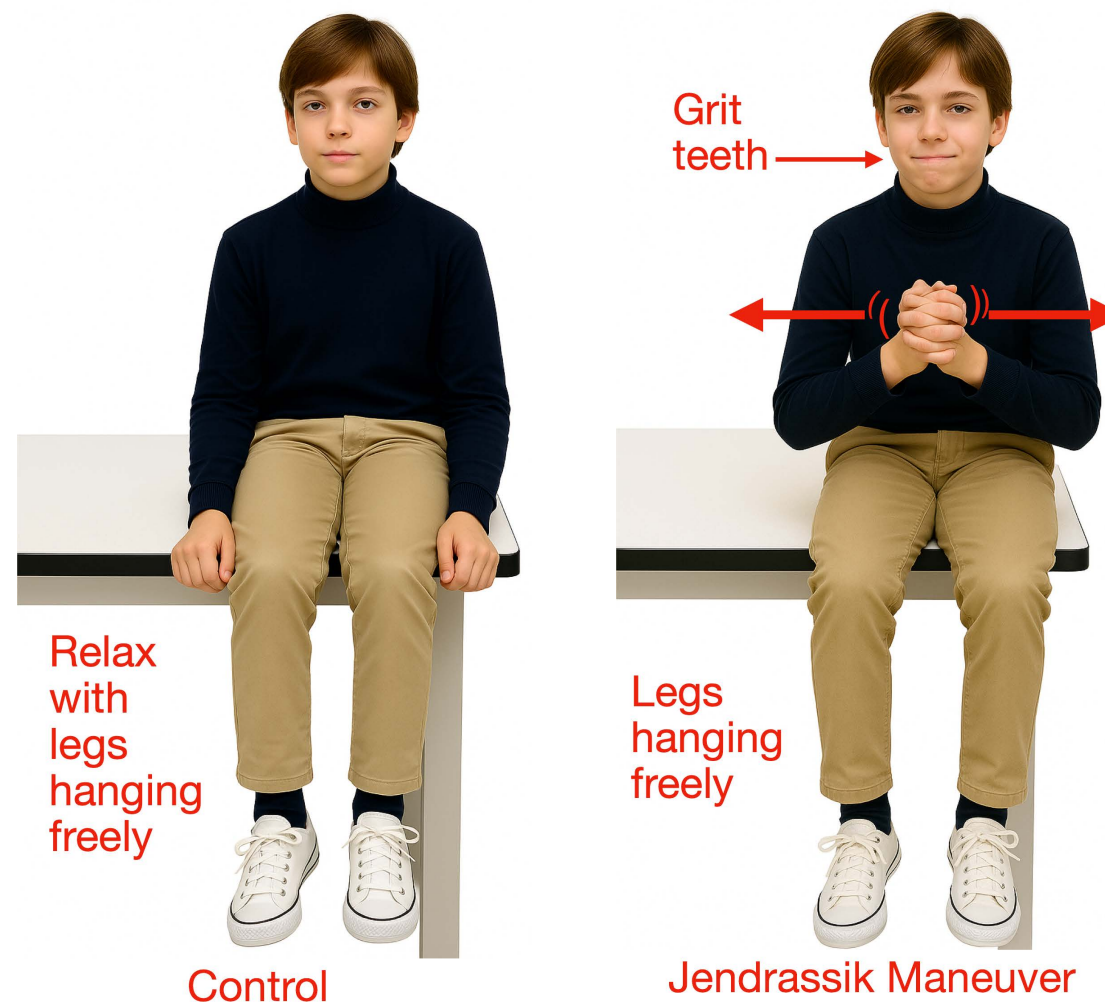


Table B

	Relaxed	Jendrassik Maneuver
Left Leg		
Right Leg		

Scoring: 0 = No movement 1 = Slight movement 2 = Normal kick 3 = Strong kick

2.4 Experiment-Protocol (Continued)

Pupillary Response (Light Reflex)

The **pupillary reflex** is an automatic adjustment of the pupil size in response to light. When bright light enters the eye, the pupil constricts to protect the retina. In dim light, the pupil dilates to allow more light in. This reflex helps maintain clear vision under changing light conditions.

- ☐ 1. Work in pairs. Choose one student to be the subject and the other to be the examiner.
- ☐ 2. The subject should sit upright in a chair in a dimly lit room (turn off room lights if possible), facing forward.
- ☐ 3. The examiner holds a penlight in one hand. With the other hand, the examiner places the side of their hand vertically between the subject's eyes to act as a shield, so light shines into only one eye at a time.
- ☐ 4. The examiner briefly shines the light into the subject's left eye while watching carefully for changes in pupil size in both eyes.
- ☐ 5. Record the observation for each pupil (left and right) in **Table C**.
- ☐ 6. Repeat the procedure, this time shining the light into the subject's right eye while using the hand shield. Record the response in both eyes.
- ☐ 7. Switch roles so each student has a chance to be both subject and examiner.
- ☐ 8. Compare results among classmates. Discuss whether all pupils responded the same way and why this reflex is important for vision and eye safety.



Table C

	Left Eye (constrict, dilate, no change)	Right Eye (constrict, dilate, no change)
Shine light in left eye		
Shine light in right eye		

3.1 Conclusions:

- Question:** Look at your results from the two-point discrimination experiment in **Table A**. Compare your results with those of your classmates. What did you find? What can you conclude, and how can you interpret the results?

In my results, when light was shined into one of my eyes, that pupil got smaller (constricted). At the same time, the other pupil also got smaller, even though no light was shining directly into it. This happened on both sides when we switched eyes.

When I compared my results with my classmates, almost everyone showed the same pattern: both pupils reacted at the same time, although the speed and strength of the response varied a little between students. Nobody's pupils stayed the same size in the light.

From this experiment, I can conclude that the pupillary reflex is automatic and works in both eyes together. This reflex protects the eyes from bright light and helps us see clearly in different lighting conditions. It also shows that the nervous system is sending signals from the eye to the brain and then back to the muscles in the iris very quickly.

- Question:** Look at your results from the knee-jerk experiment in **Table B**. Compare your results with those of your classmates. What did you find? What can you conclude, and how can you interpret the results?

In my results, I saw that my leg kicked forward when the tendon below my kneecap was tapped. The strength of the kick was usually scored as a "2" (normal). When I did the Jendrassik maneuver—clasping my hands and pulling outward—my kick was stronger, often scored as a "3."

When I compared my results with my classmates, I noticed that almost everyone showed some kind of reflex, although the strength varied from person to person. Some students had a stronger reflex in one leg compared to the other. Almost all students had a stronger response when they did the Jendrassik maneuver.

From this experiment, I can conclude that the knee-jerk reflex is automatic and controlled by the spinal cord, not by conscious thought. The Jendrassik maneuver made the reflex stronger because it distracted the subject and increased activity in the spinal cord. The experiment shows how reflex arcs protect us by allowing quick, automatic responses that help with balance and posture.

3.1 Conclusions:

3. **Question:** Look at your results from the pupillary response experiment in **Table C**. Compare your results with those of your classmates. What did you find? What can you conclude, and how can you interpret the results?

In my results, when light was shined into one of my eyes, that pupil got smaller (constricted). At the same time, the other pupil also got smaller, even though no light was shining directly into it. This happened on both sides when we switched eyes.

When I compared my results with my classmates, almost everyone showed the same pattern: both pupils reacted at the same time, although the speed and strength of the response varied a little between students. Nobody's pupils stayed the same size in the light.

From this experiment, I can conclude that the pupillary reflex is automatic and works in both eyes together. This reflex protects the eyes from bright light and helps us see clearly in different lighting conditions. It also shows that the nervous system is sending signals from the eye to the brain and then back to the muscles in the iris very quickly.

3.2 Discussion:

1. **Question:** Why do reflexes happen without us having to think about them, and why is this important for survival?

Reflexes bypass the brain's higher thinking centers and are processed in the spinal cord. This makes them much faster than voluntary actions. They are important for survival because they allow the body to react immediately to danger or changes, like pulling your hand away from something hot or adjusting your balance when you slip.

2. **Question:** What do the results of the two-point discrimination test tell us about how the brain "values" different parts of the body?

The test shows that body parts like the lips and fingertips are more sensitive than areas like the calves or back of the hands. This means the brain gives more space in the sensory cortex to areas that are important for exploring and interacting with the environment. It suggests that the brain "values" precision and detail where we need it most.

3. **Question:** How do the knee-jerk and pupillary reflexes demonstrate the idea of a reflex arc?

Both reflexes show how a signal can travel quickly from a receptor, to the spinal cord or brainstem, and then back to a muscle without needing higher-level brain involvement. In the knee-jerk, the signal goes to the spinal cord and back to the leg muscles. In the pupillary reflex, the signal goes to the brainstem and back to the muscles in the iris. Both are automatic and protective responses.

3.2 Discussion:

4. **Question:** What do reflexes and sensory maps (like the homunculus) together teach us about how the nervous system is organized?

Reflexes show that the nervous system is designed for speed and protection, while the sensory homunculus shows that some areas of the body are given more importance for sensing detail. Together, they teach us that the nervous system is specialized: some pathways are built for fast reactions, while others are organized for careful, detailed processing. This balance allows us to be both safe and skillful in the world.

5. **Question:** Reflexes are very fast and automatic. How do they compare to more complex thinking and decision-making, and why does the brain need both?

Reflexes allow us to react instantly to protect ourselves, like blinking when something flies toward our eye. Complex thinking and decision-making take longer but let us solve problems, plan, and learn from experiences. The brain needs both systems because sometimes speed is most important for safety, while at other times careful processing is needed for understanding and making good choices. Together, they make us adaptable and able to survive in many different situations.